

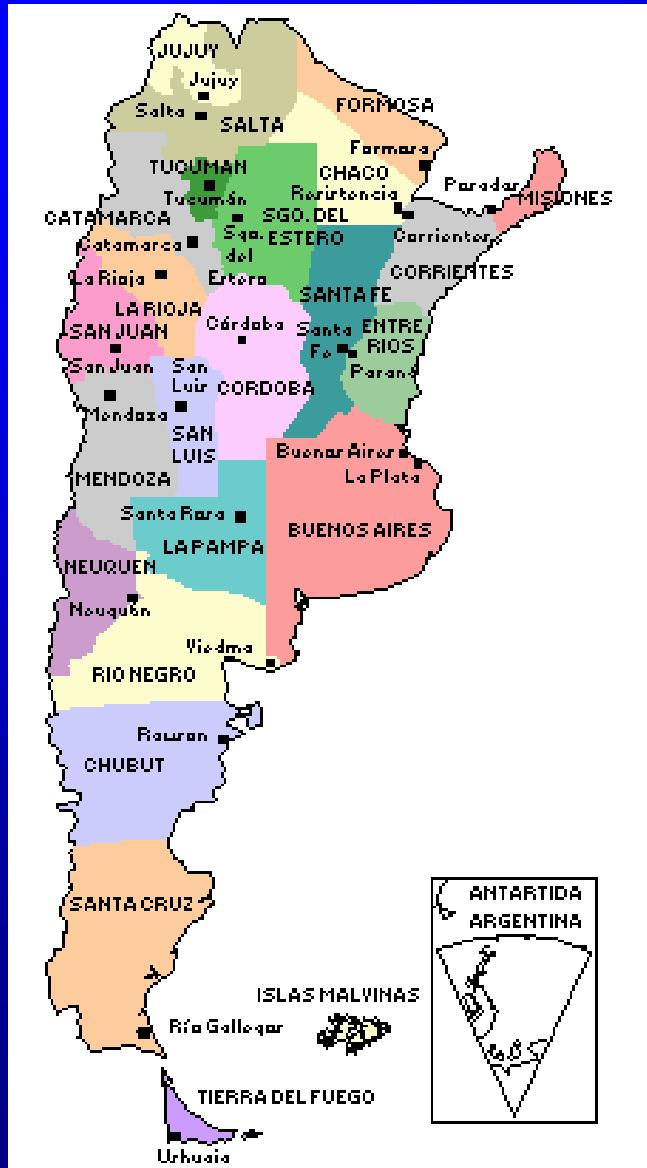
HEALTH and SATELLITE

**"Using space information in
Epidemiology, different approach for
Vector and Rodent-Borne Disease"**



NOAA-MIAMI/USA

ARGENTINE A SPACE COUNTRY



Based on its geographical extension, population distribution and economic activities, such as agriculture, forestation, mining, natural resources; Argentine can be defined as a ***“Space Country”***. It means that for Argentina, the **Space Information is vital for its socio-economic development.**

2766890 km²
37000000 inhabitants
87% urban population



Institute on Space Studies “Mario Gulich”

MULTIDISCIPLINARY AND INTERINSTITUCIONAL APPROACH



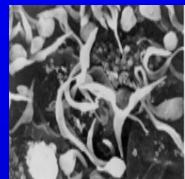
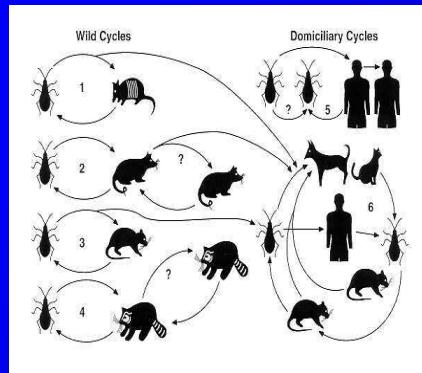
Created by agreement between CONAE and the National University of Córdoba. This institute is initially devoted to offer graduate workshops and courses in basic space technology and its applications. The main goal of these activities is the generation of **Early Warning Systems** on environmental emergencies using Space Information.



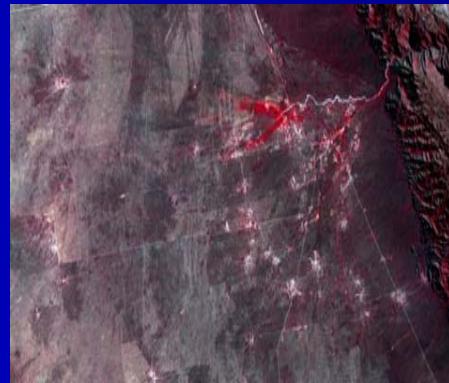
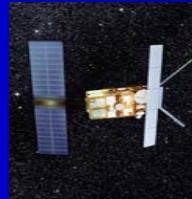
LANDSCAPE EPIDEMIOLOGY

- “Landscape Epidemiology”, is a relatively new interdisciplinary approach that involves the **characterization of eco-geographical** areas where diseases develop.
- Landscape Epidemiology can be understood as part of a **second-generation-application** of remotely sensed data where the target (the vector or reservoir host) can not be seen directly with satellite images.
- It is a holistic approach which takes into account the relationships and interactions between the different elements of ecosystems under the assumption that the biological dynamics of both host and vector population are **driven by landscape elements** such as temperature and vegetation.

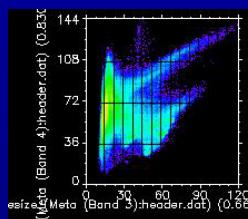
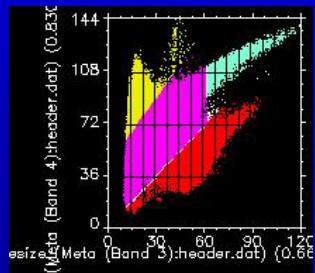




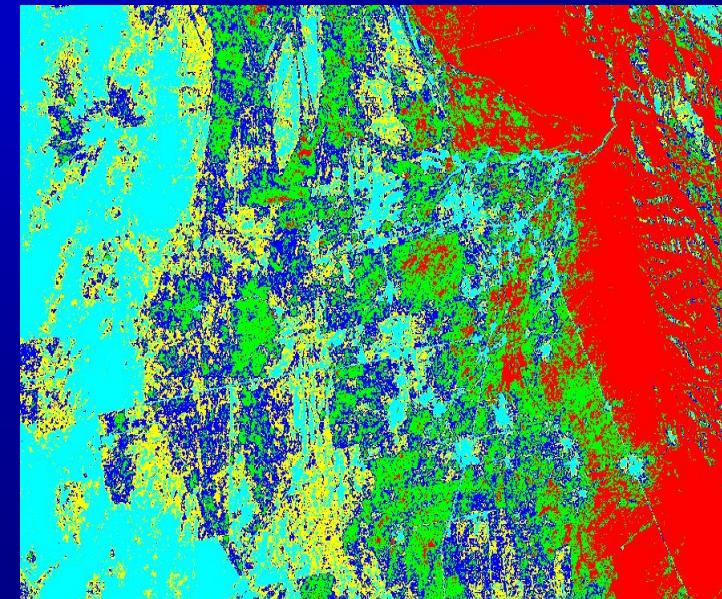
Field data



Space Data



Modelling



RISK MAP





Instituto de Altos Estudios Espaciales
"Mario Gulich"



Primeras Jornadas Nacionales sobre Aplicaciones de la Información Espacial a la Salud Humana

30 y 31 de Julio 2001

Coorganizan:

- Coordinación Nacional de control de Vectores del Ministerio de Salud de la Nación
- Red Argentina de estudio de artrópodos Vectores de Enfermedades humanas

Las presentes JORNADAS NACIONALES pretenden dar el impulso inicial para la interacción de todos los sectores vinculados al uso de información espacial en problemas epidemiológicos, comenzando el desarrollo de un foro de trabajo interdisciplinario basado en los lineamientos del Instituto de Altos Estudios Espaciales Mario Gulich



Imágenes del satélite Argentino SAC-C

Delta Río de La Plata, Bs.As. Laguna de Mar Chiquita, Córdoba

Objetivos Específicos :

- Expandir el uso de las tecnologías espaciales por parte de la comunidad dedicada al cuidado y prevención de la salud humana, a través de entrenamiento, educación y proyectos de aplicación.
- Asistir a los investigadores en el campo de la salud en el uso de las facilidades del Instituto Gulich, para alcanzar sus logros y objetivos.
- Proyectar las tecnologías espaciales futuras para su uso en el área de la salud y contribuir a desarrollos específicos y sus aplicaciones.

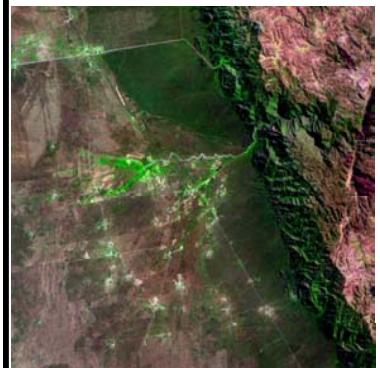


Imagen Landsat TM – Chancani – Córdoba, Argentina



Lugar: Instituto Gulich, Centro Espacial Teófilo Tabanera
Ruta C45, Km 8, Falda del Carmen, Córdoba
Inscripción: Sin Cargo, Cupo Limitado
Informes: 03547 - 431000 int 1035, Fax 03547 - 424566

Imagen AVIRIS – Cap.Fed. – Bs.As., Argentina

DIFERENTES PROJECTS WITH
NATIONAL AND LOCAL
HEALTH INSTITUTIONS,
UNIVERSITIES AND RESEARCH
CENTERS ON:

DENGUE
MALARIA
HANTAVIRUS
ARG. HEMORRAGIC FEVER
LEISHMANIASIS
CHAGAS
ETC.



Ministerio de Salud de la Nación: Cor. Nac. Control de vectores Malaria

Ministerio de Salud de la Nación: Cor. Nac. Control de vectores Dengue

Ministerio de Salud de la Nación: Ins. Nac. Enf. Virales FHA-Hanta

Ministerio de Salud de la Nación: Cen. Nac. Endemo-epidemias Leishmaniasis

CRILAR /Universidad de Buenos Aires – NASA : Enfermedad de Chagas

Participacion activa en los programas Nacionales de Dengue-Chagas y FHA

Comisión Intergubernamental Mercosur/Bolivia/Chile Chagas-Dengue

Programa Internacional MATE/ CNES-CONAE Dengue

Cooperación con programas Nacionales en Latinoamérica:

Uruguay, Chile, Bolivia, Venezuela, Peru, Brasil, Paraguay, Colombia, Mexico

Seminario regional sobre Aplicaciones de la tecnología espacial a la salud

ONU, ESA, EURISY, CNES (septiembre 2005)



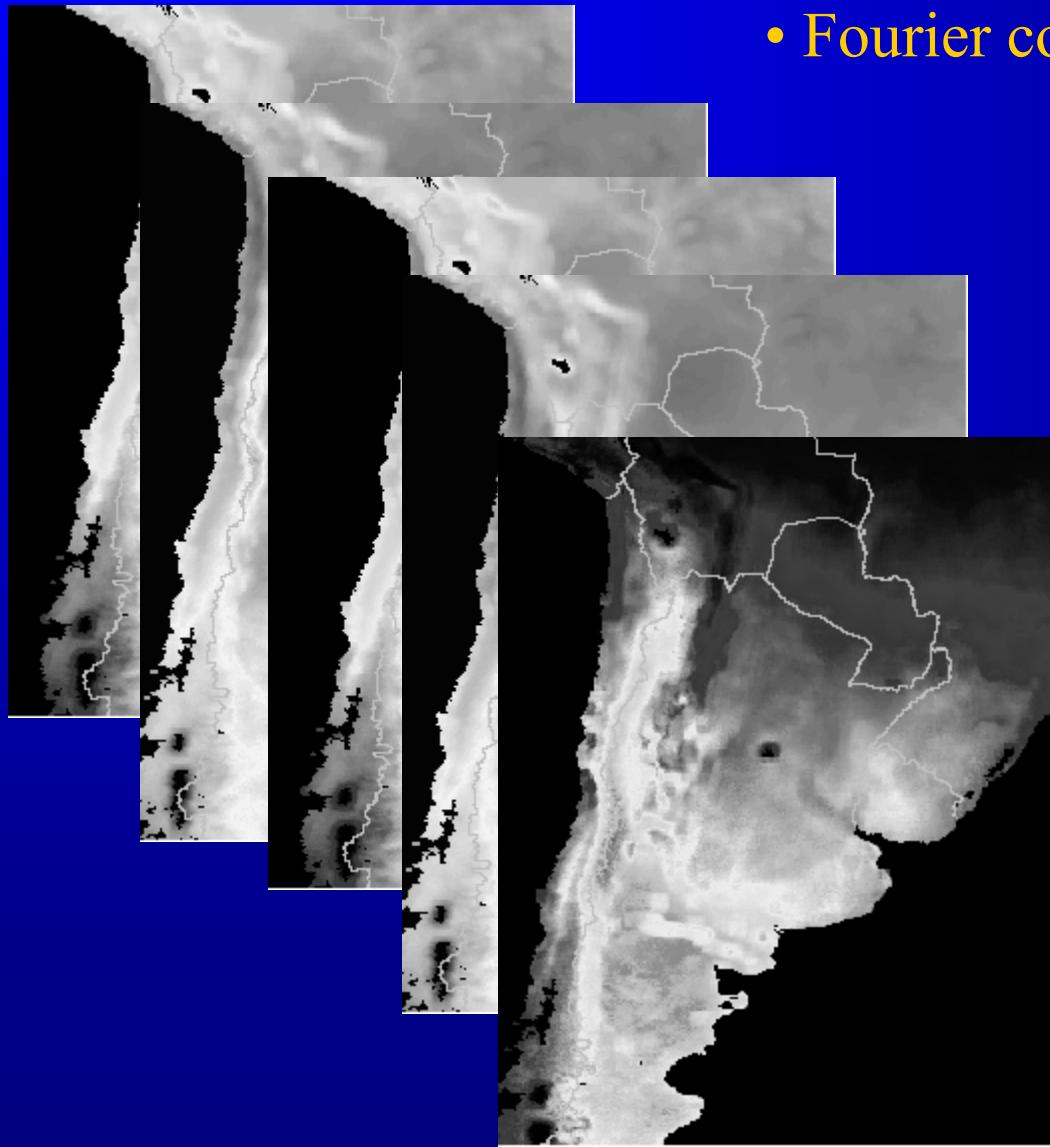
FIRST EXAMPLE

Geographical distribution of rodent species with epidemiological relevance (Hantavirus and Argentine Hemorrhagic fever host)

Typical statistical approach, based on historical vegetation and temperature data derived from NOAA series satellite imagery, including also precipitation and elevation data.



Geographic Distribution *Calomys*
musculinus, *Oligoryzomys*
longicaudatus and *Oligoryzomys*
Flavescens



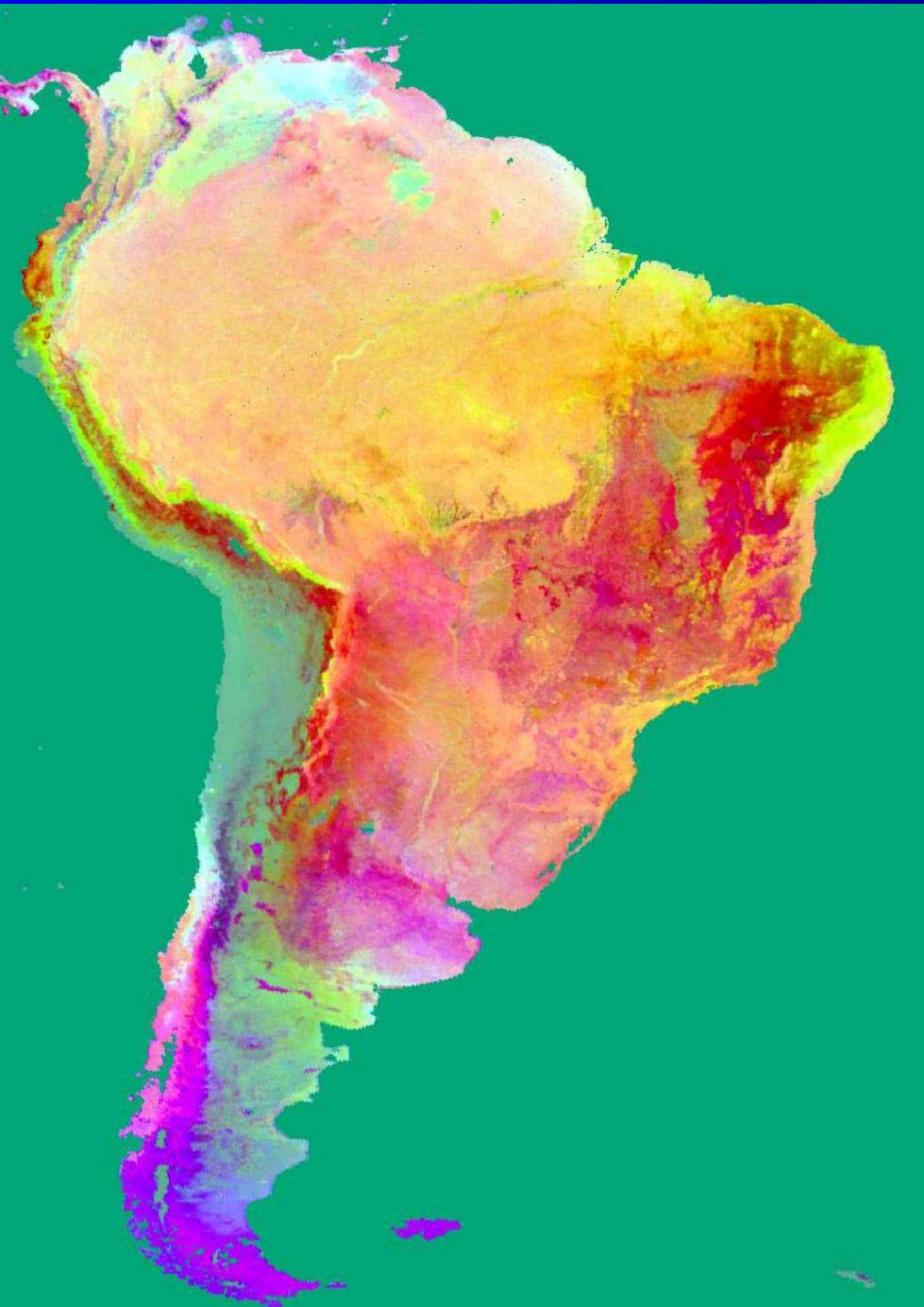
- Average and variance
- Principal components
- Fourier components

Each image represent a decadal
or monthly image of each
variable

Temperature - Precipitation -
Vegetation

- 1) 1982-1992 AVHRR decadal serie
(aac.gsfc.nasa.gov) → Ts, NDVI
- 2) Precipitation
- 3) DEM

Temperature



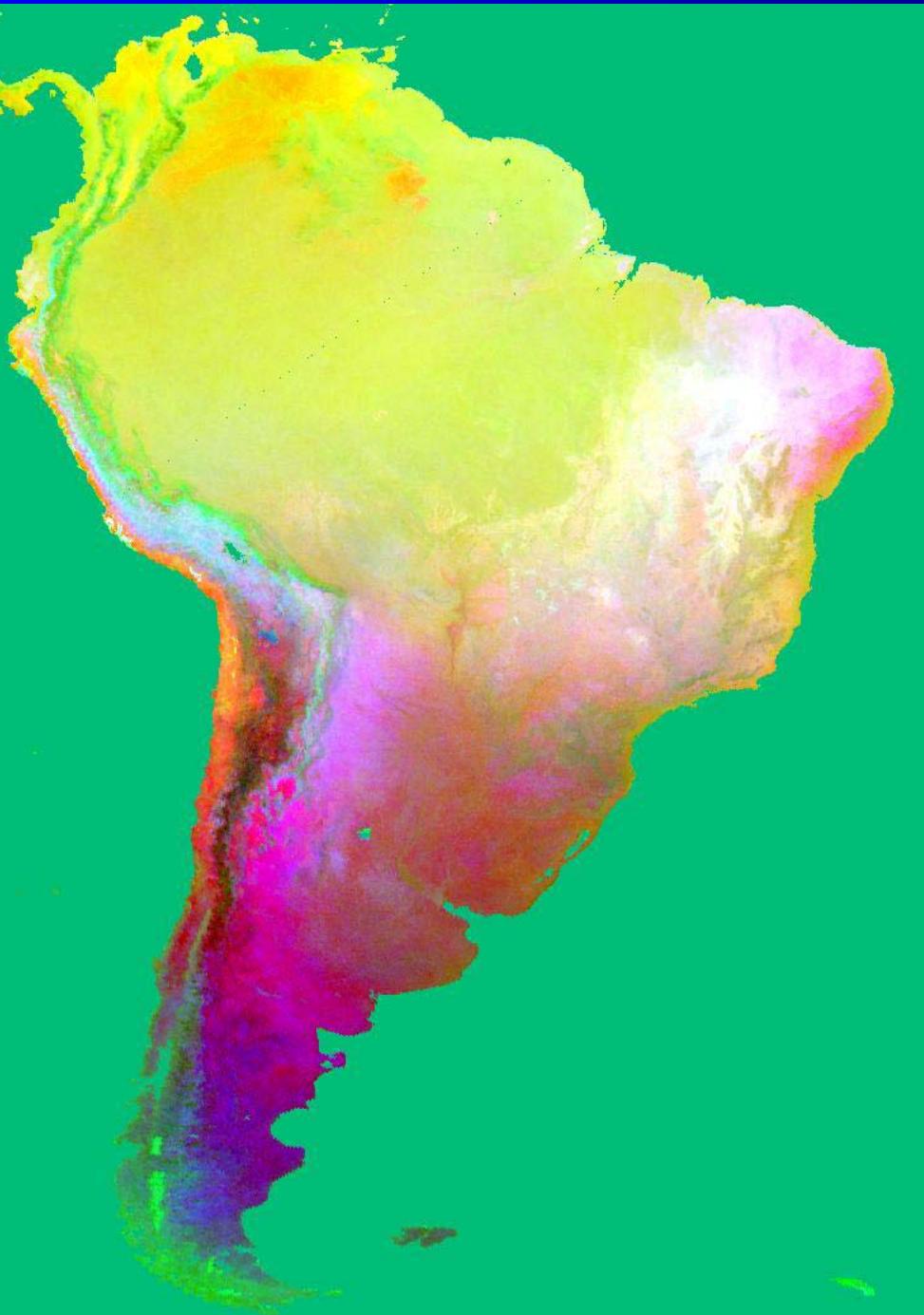
R= 1 CP

G= 2 CP

B= 3 CP



Vegetation



R= 1 CP

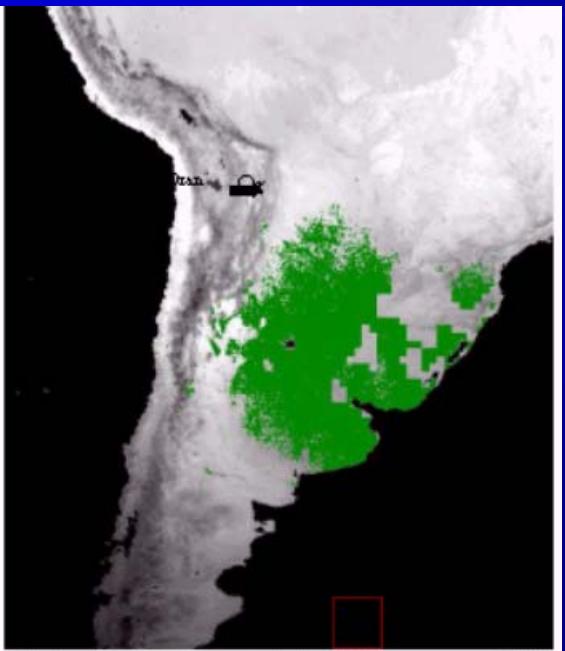
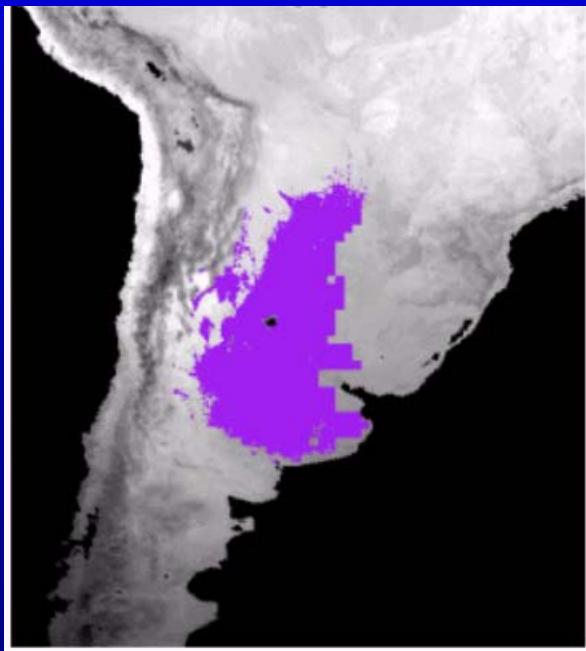
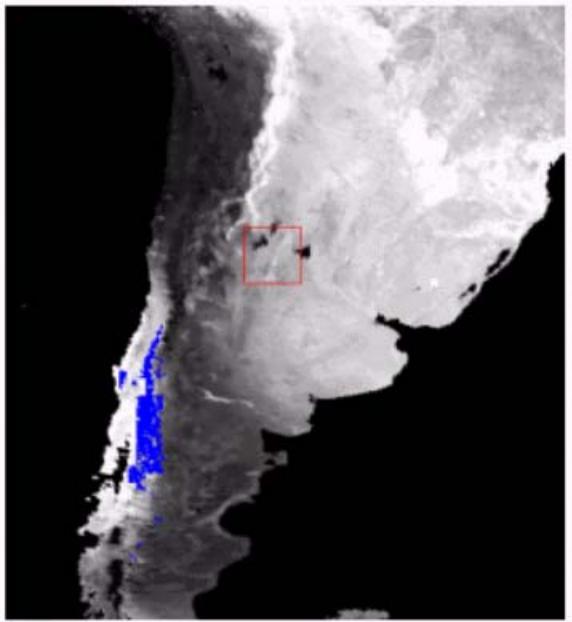
G= 2 CP

B= 3 CP





*Oligoryzomys
longicaudatus*



Calomys Musculinus -- *Oligoryzomys Flavescens*



Numerical modelling of population dinamic

Fiebre Hemorrágica Argentina – rodent borne disease



In contrast to the more common statistical approach, this model incorporate satellite-derived environmental data in a causal approach

<http://www.conae.gov.ar/aplicaciones/aqui/FHAE.pdf>

$$\frac{dX}{dt} = \alpha(1 - N)X - \beta XY - \frac{X}{\tau}$$

$$\frac{dY}{dt} = \beta XY - \frac{Y}{\tau m}$$

X = Non-infected host population as a fraction of carrying capacity.

Y = Persistently infected host population as a fraction of carrying capacity.

N = Total *C. musculinus* population, in this case N=X+Y

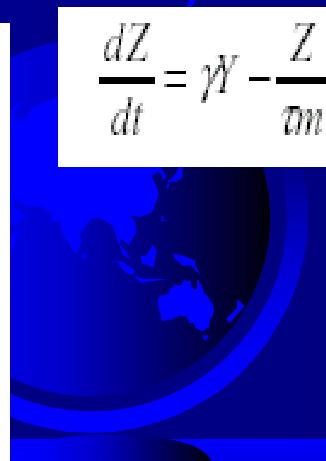
In this non-dimensional approach the maximum possible value for "X" or "Y" is 1. Then $1 - N = 1 - (X + Y)$ is the free fraction of the carrying capacity (available to be occupied by new births).

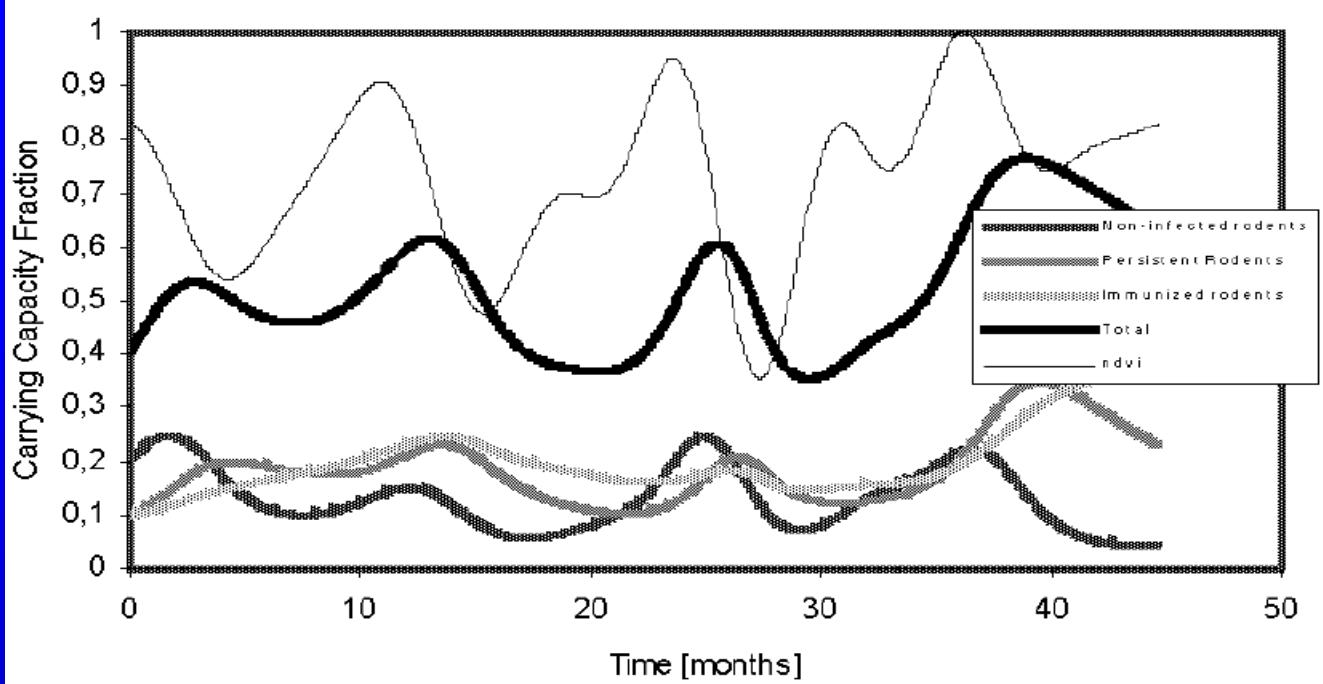
τ (tau) = maximum "mean life span" (equal for both, infected and non infected rodents) producing a non infected host mortality rate X/τ .

α (alpha) = potential (per capita) reproductive rate in absence of carrying capacity constrains.

β (beta) = average number of non-infected hosts that an infected host can infect during its lifetime. The term βXY is the infection rate.

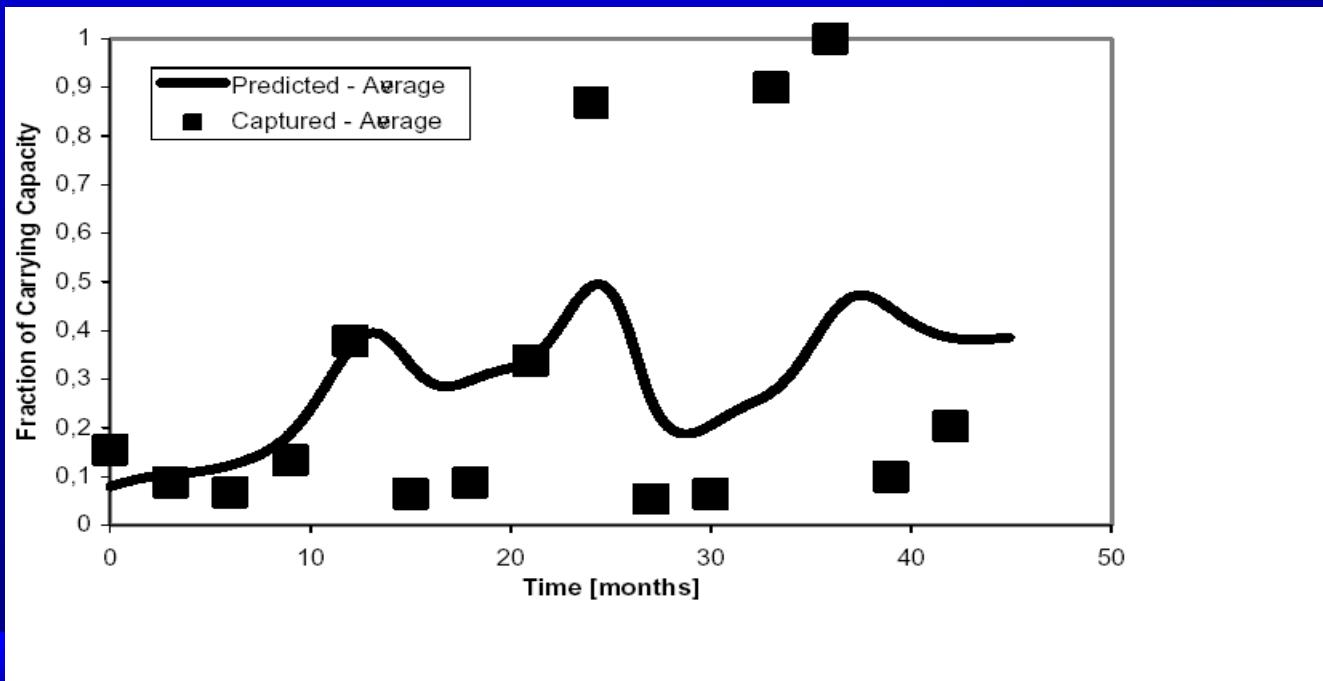
$$\frac{dZ}{dt} = \mathcal{W} - \frac{Z}{\tau m}$$





MODELS RESULTS

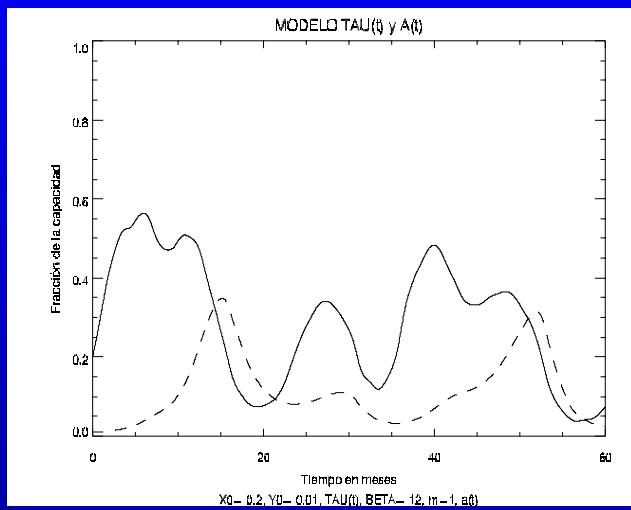
AND



MODEL
VS
FIELD
DATA

Numerical modelling of population dinamic

Fiebre Hemorrágica Argentina – rodent borne disease



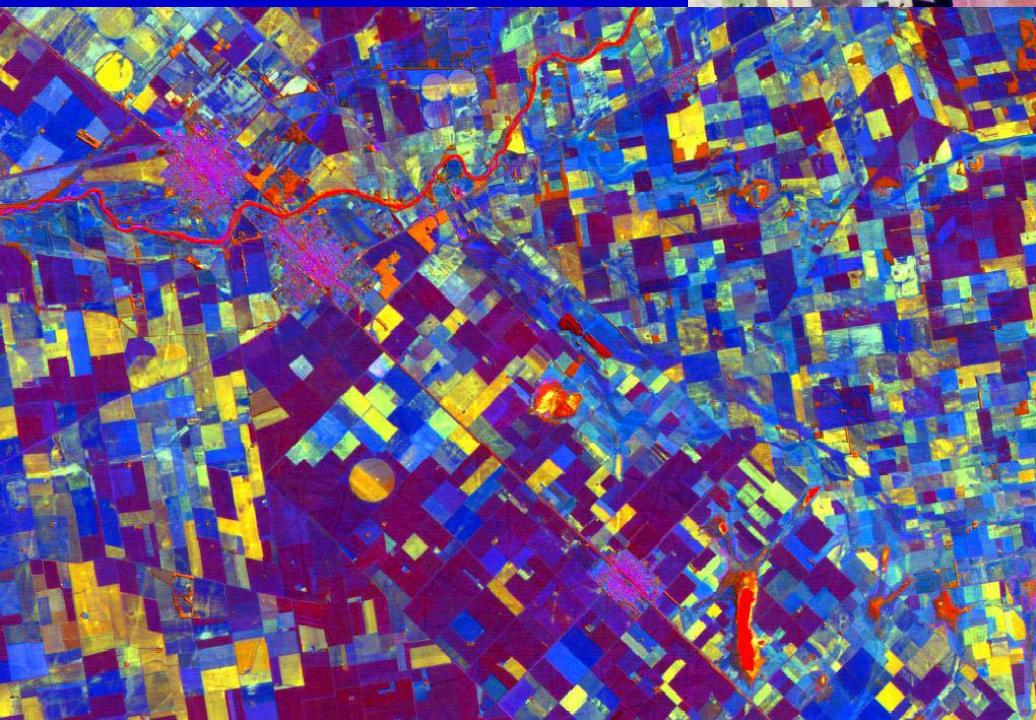
Automata Cellular Model



RURAL RODENT AHF

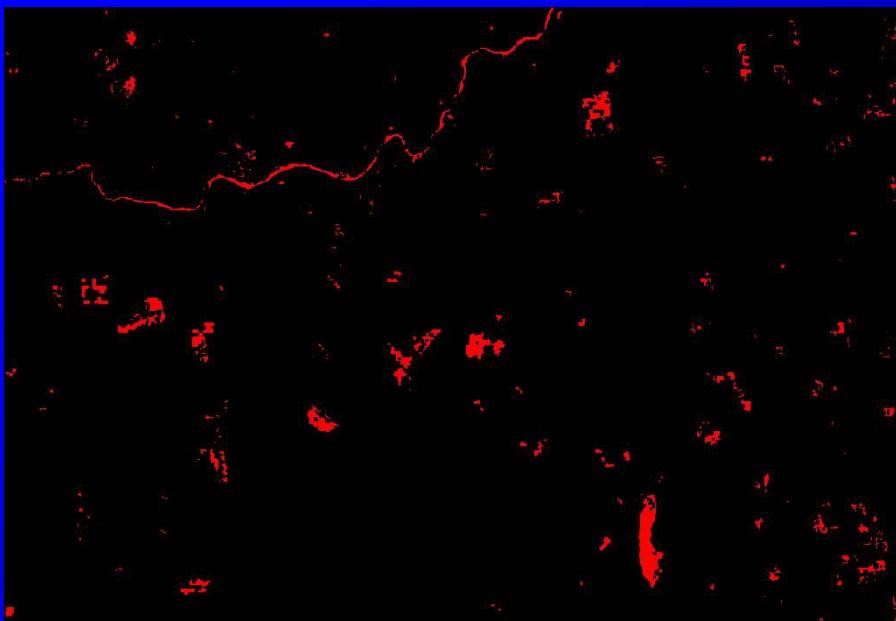
Original Image L7

B 7-5-2



Tasseled Cup

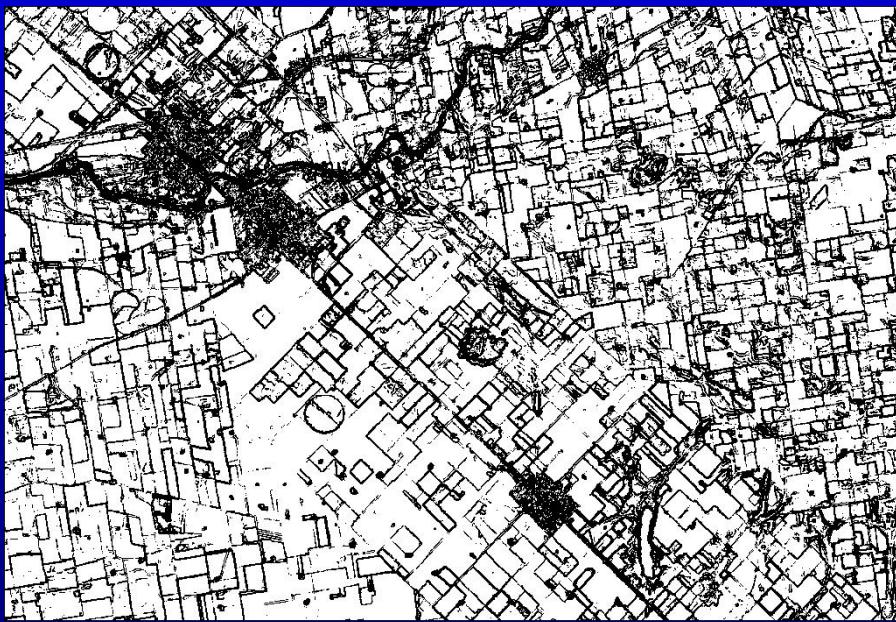
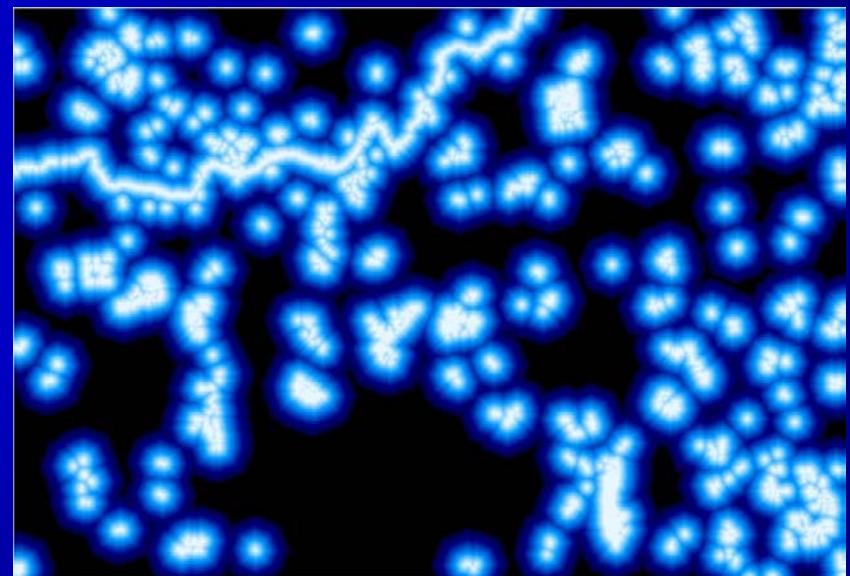
3-2-1



Water

Borders

Buffers





Automata Cellular Model

RURAL RODENT AHF

DEFINE A GODDNESS POTENTIAL FOR EACH
PIXEL

GREENNESS

WETNESS

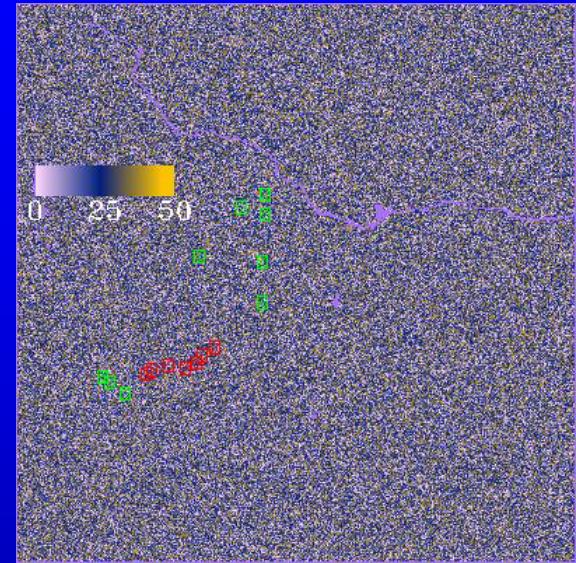
Distance to water source and lineal habitat

Include carrying capacity

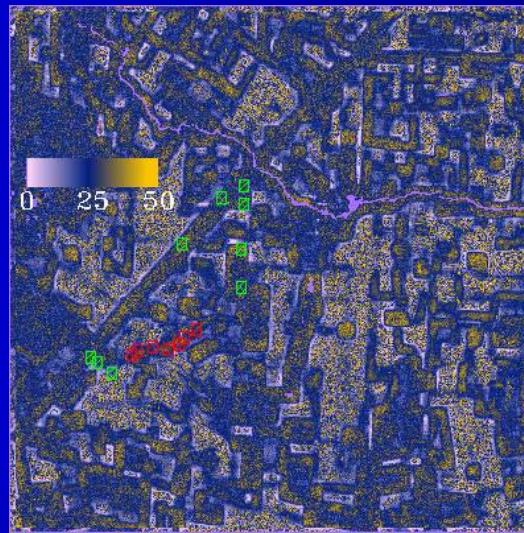
QUANTIC TUNELLING



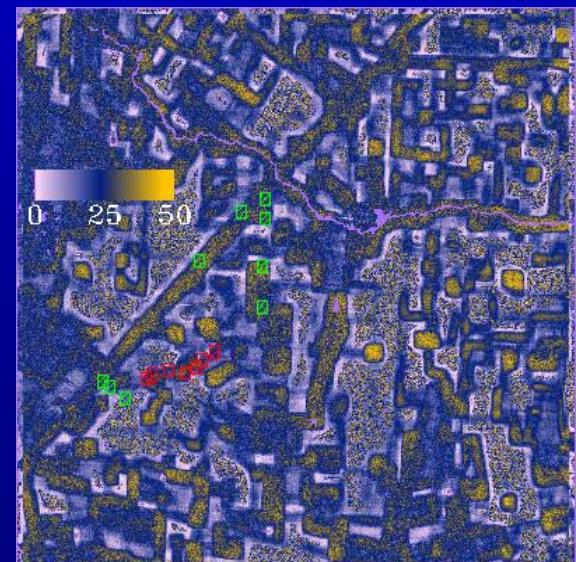
Cellular Automata



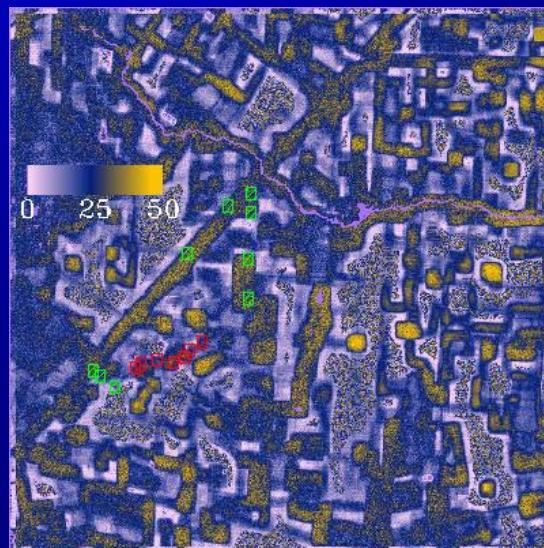
Start



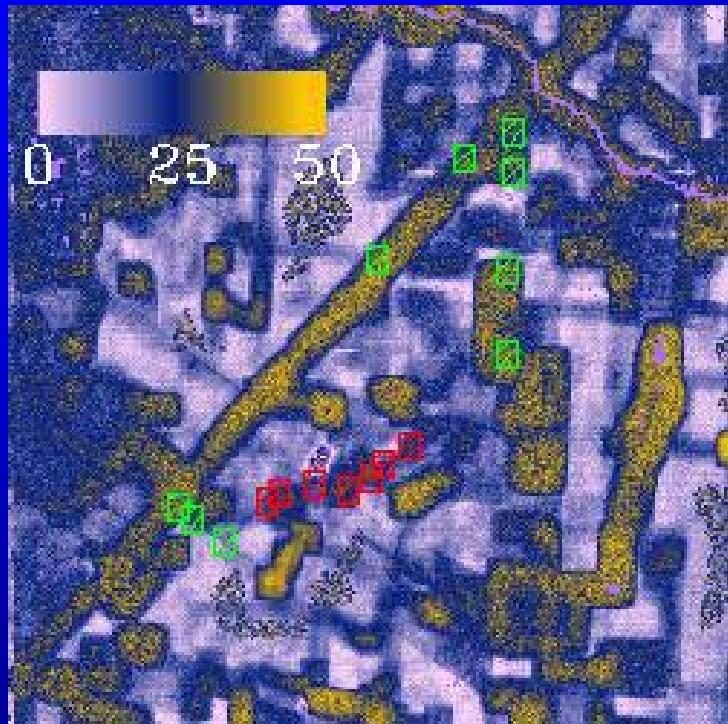
500



2000



4500



Landsat 7



SAC-C



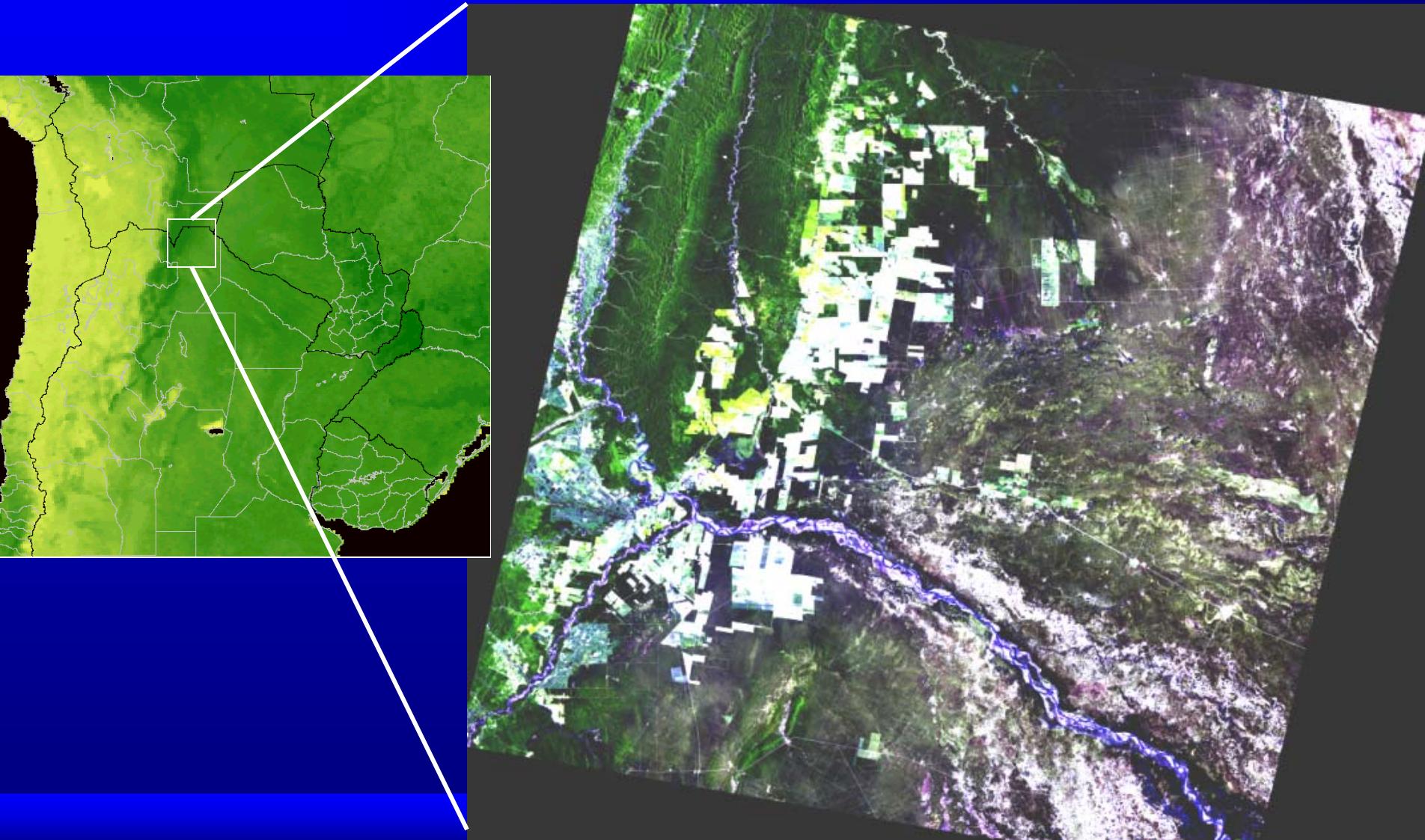
Dengue Epidemiology in Tartagal (Salta, R Argentina)

AS PART OF MATE PROJECT
CONAE - CNES



Geographic location of the area of interest

<http://www.conae.gov.ar/aplicaciones/aqui/vectoresE.pdf>

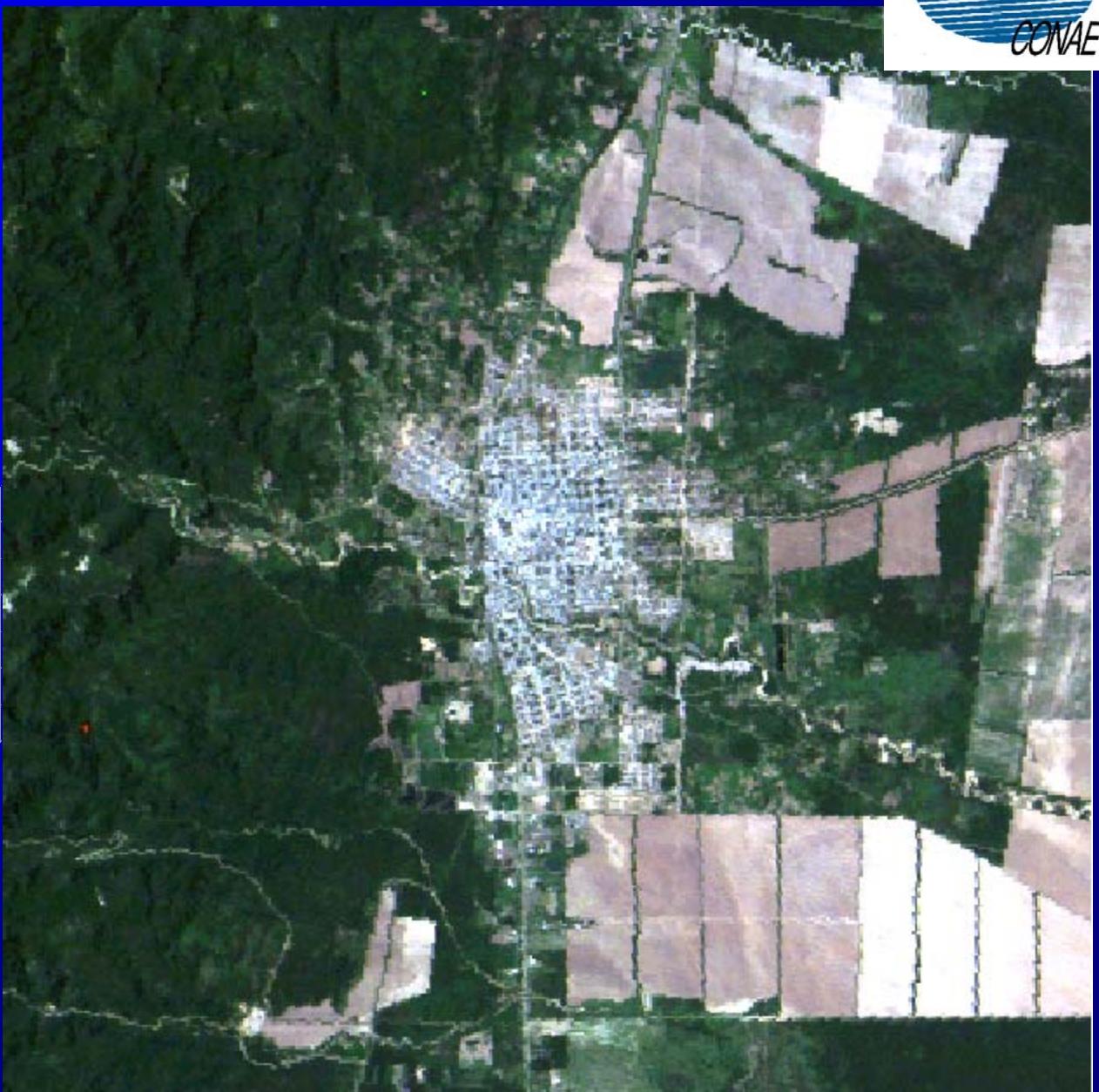


TARTAGAL

Population 60500

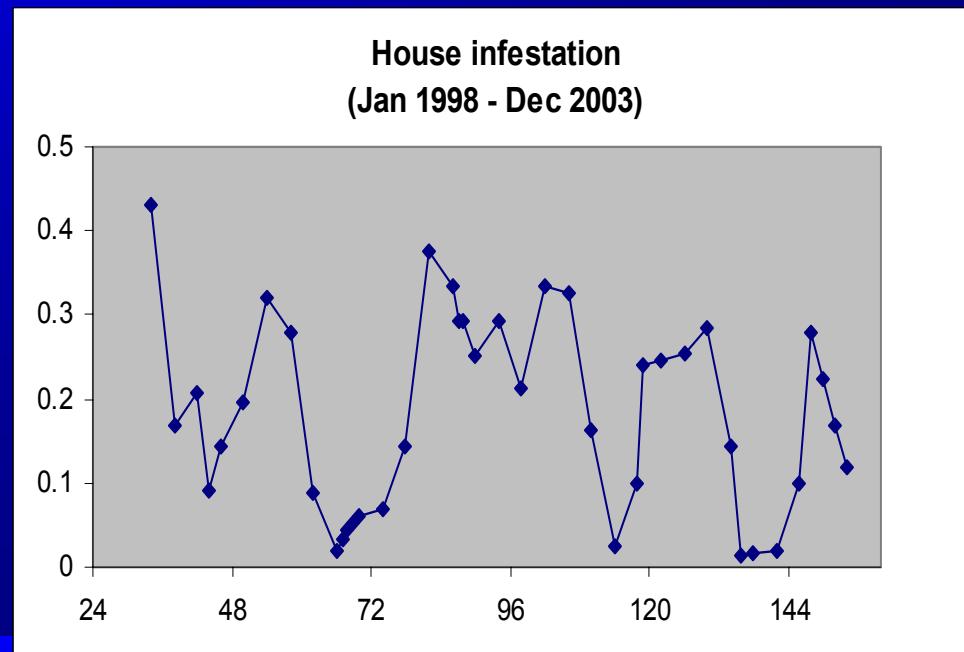
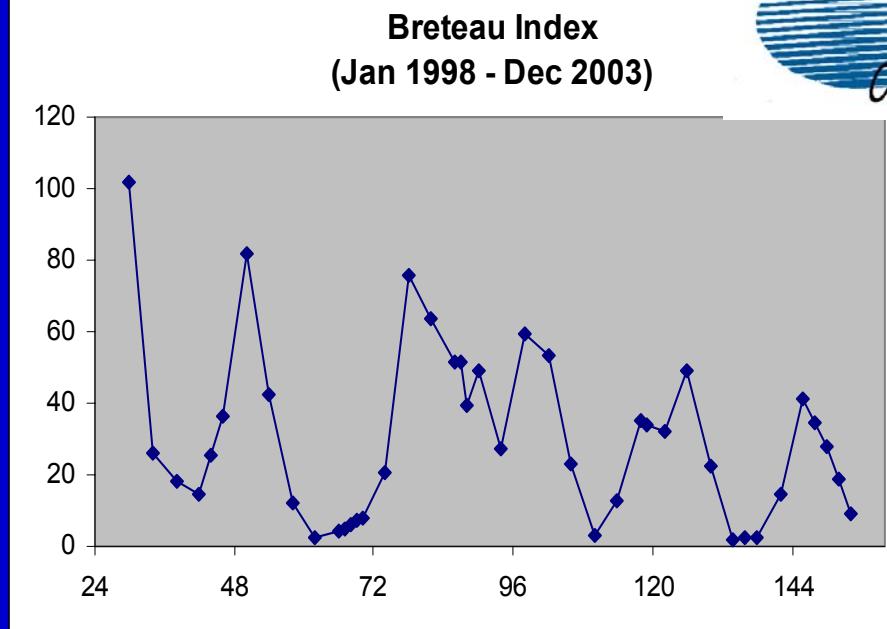
Dengue (4 loc.):

Year	Clinical	ELISA	Serotype
	Suspects	Ig.M (+)	
1998	839	341	Den2
1999	148	9	Den2
2000	148	31	Den1
2001	61	5	
2002	851	224	Den1



Objective:

Build a model for the temporal change of observed Breteau and House Infestation Indexes for Tartagal between 1998 – 2003

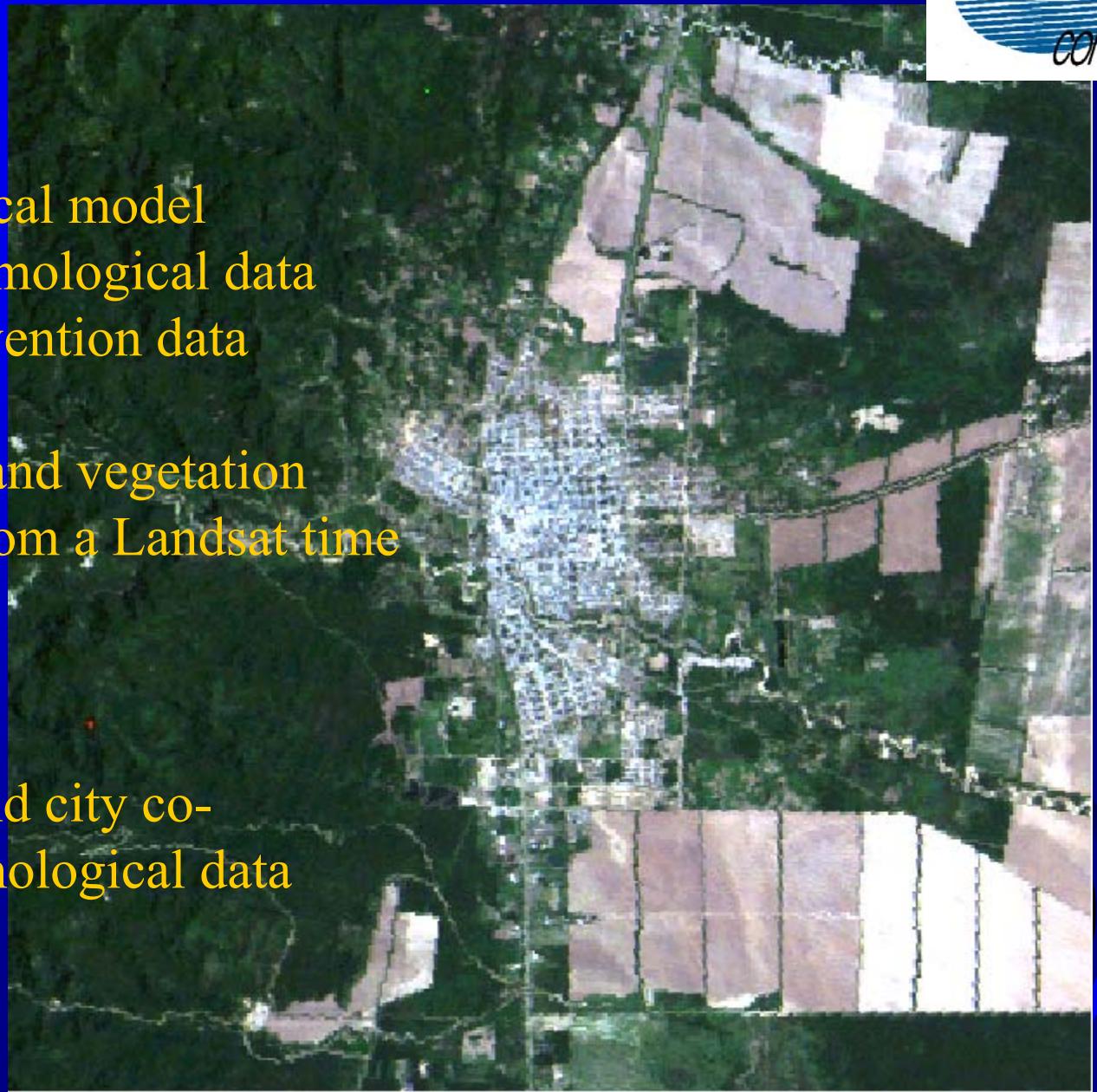


General approach

- To build a statistical model
- Use existing entomological data
- Use control intervention data
- Use rainfall data
- Use temperature and vegetation index estimation from a Landsat time series 1998 – 2003

Main assumption:

Data from forest and city co-variates with entomological data



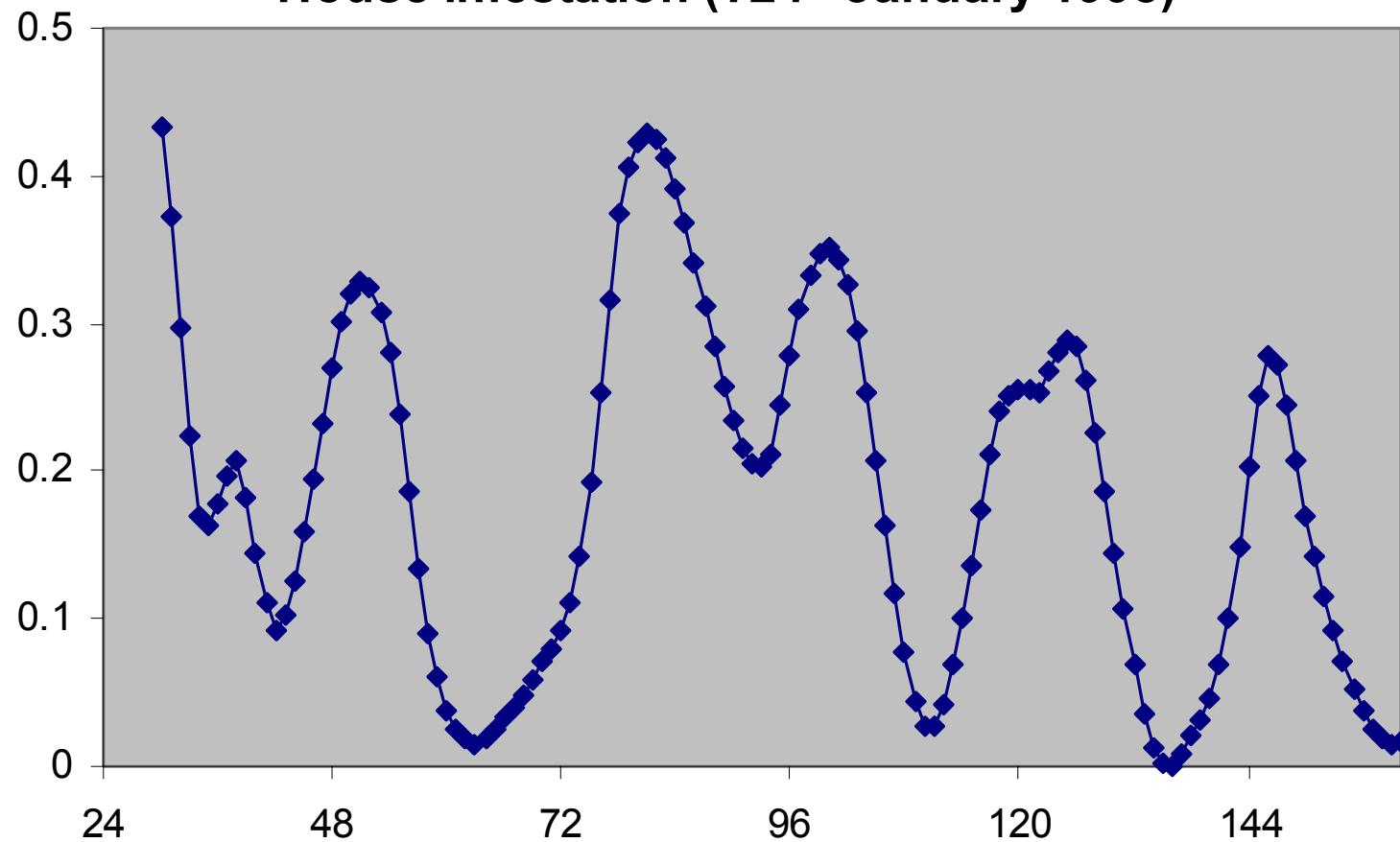
MODEL 2

Variables for Model 2

AREA	Variable	Statistic
FOREST	NDVI	AVG
	TEMPERATURE	VAR
CITY	NDVI	AVG
	TEMPERATURE	VAR
RAINFALL	NDVI	AVG
	TEMPERATURE	VAR
	INTERVENTION	AVG
	CONTROL	VAR

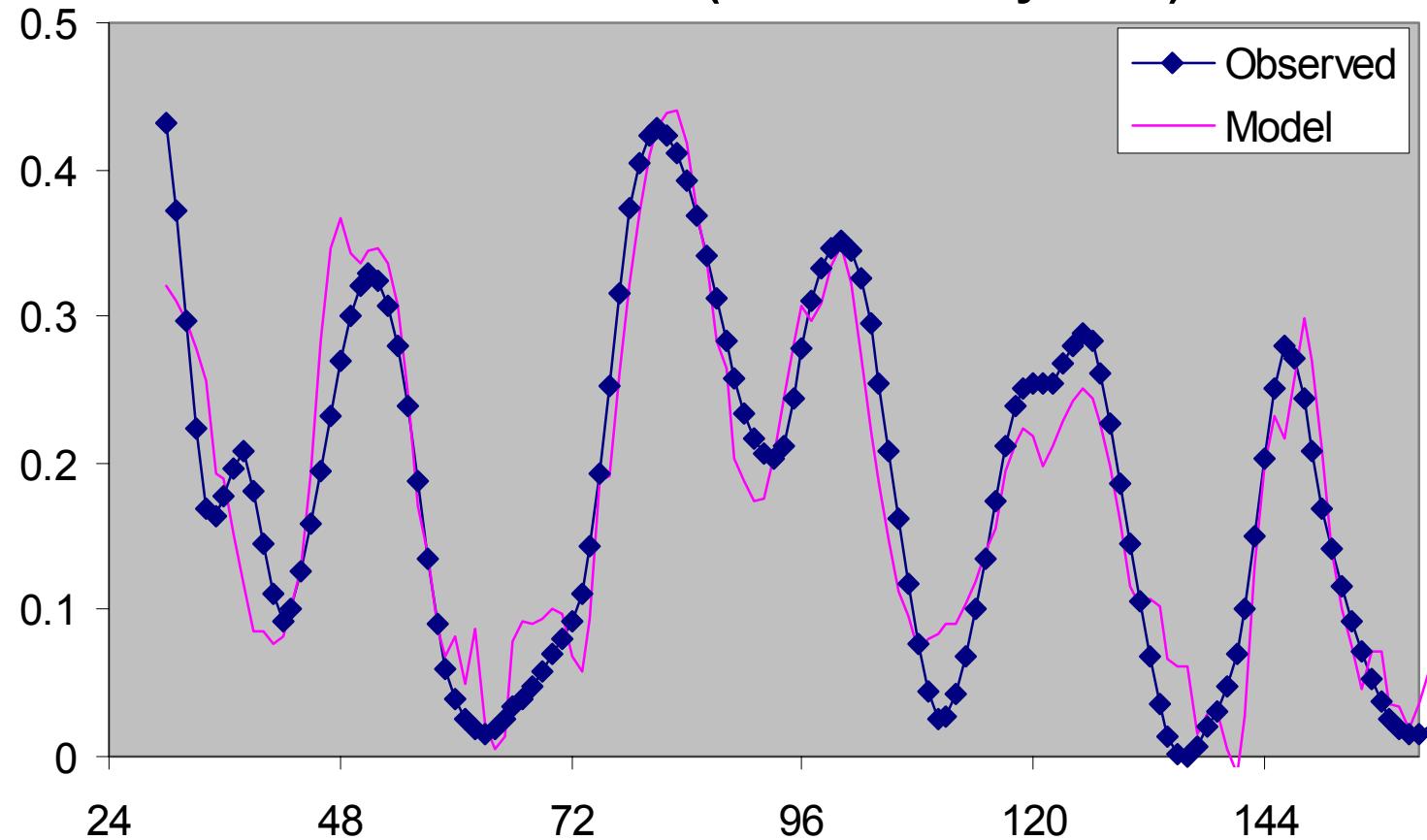


House infestation (T24= January 1998)

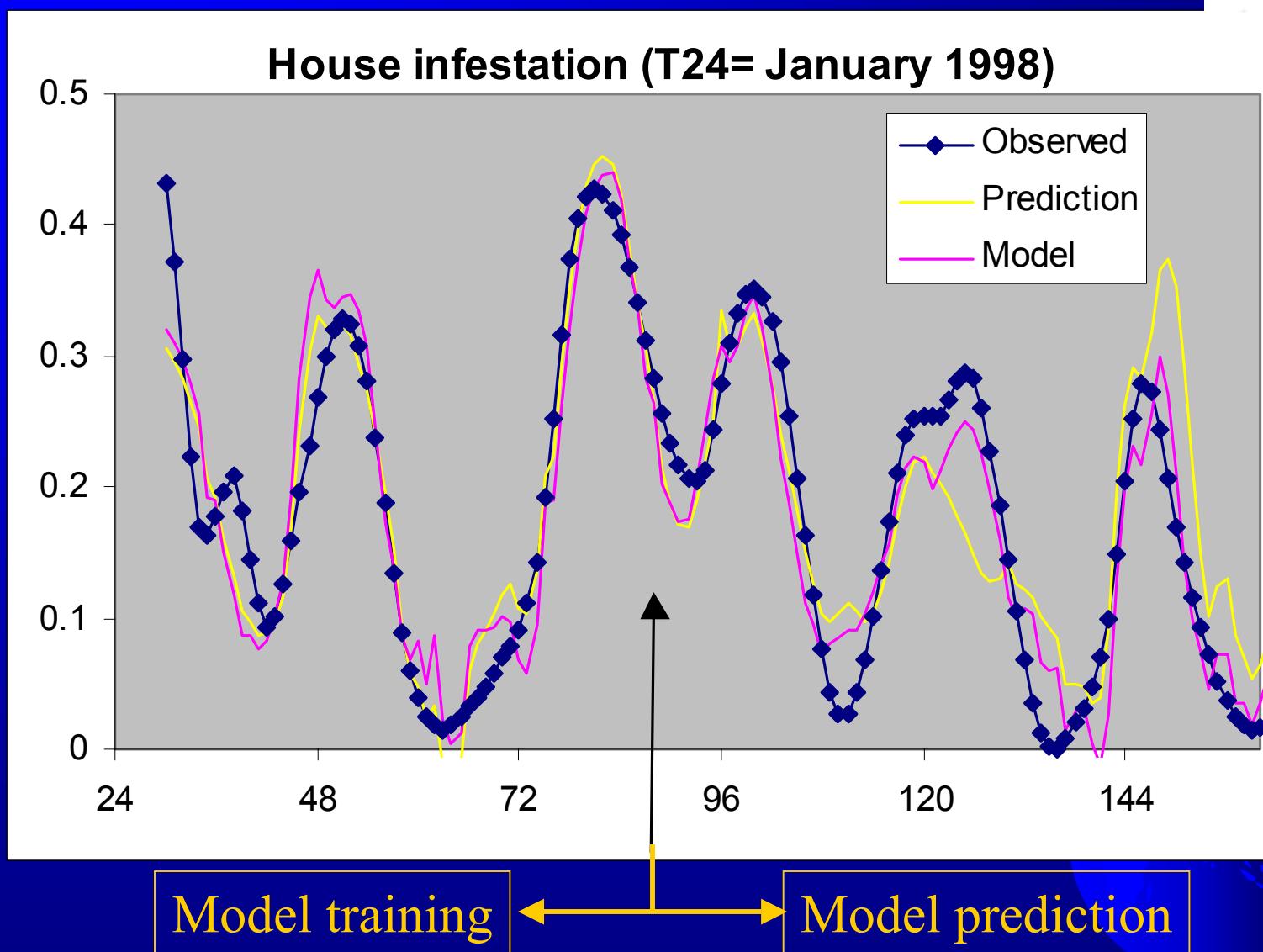


Field data after a spline function fit

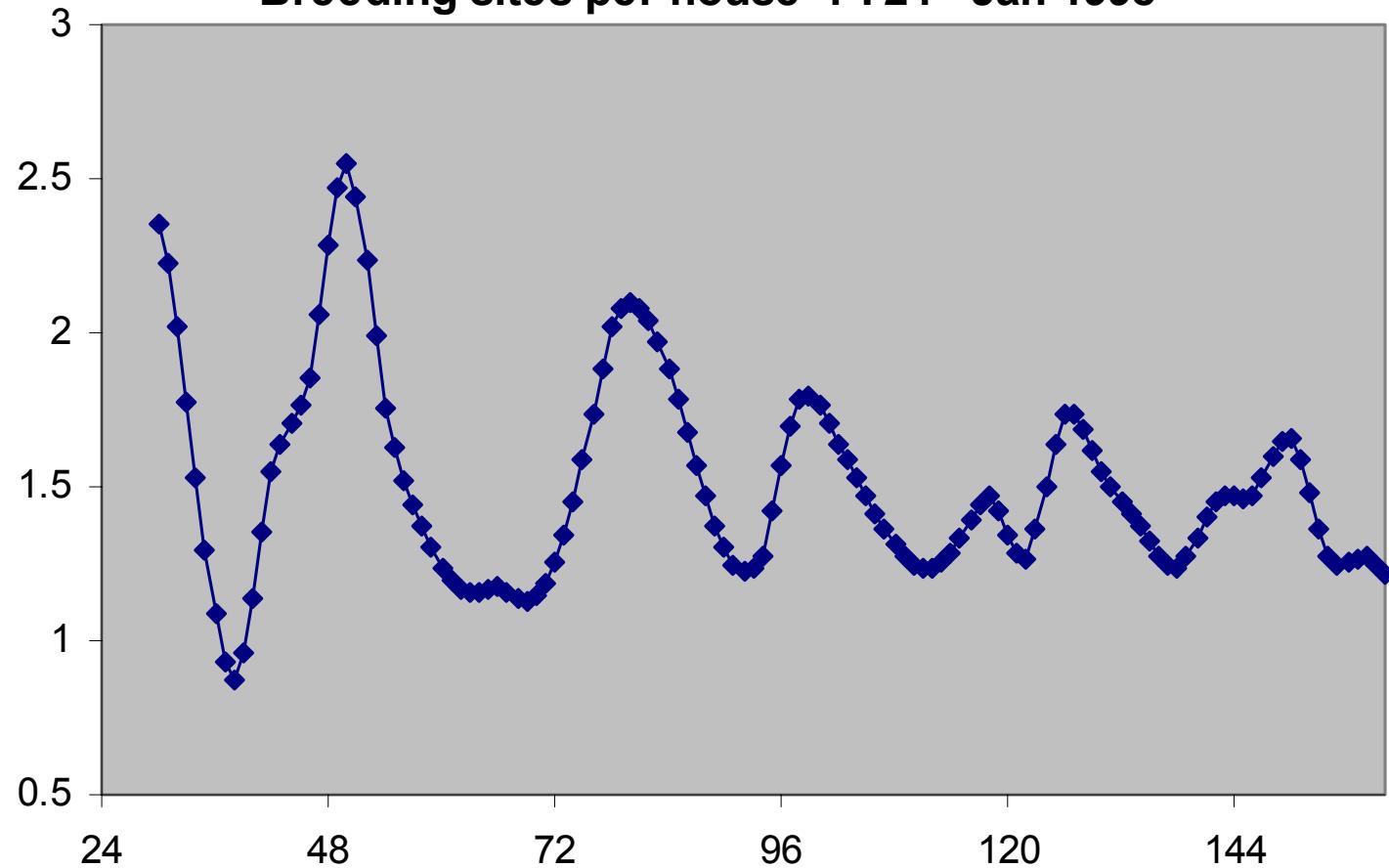
House infestation (T24= January 1998)



TIME LAGS OF THE VARIABLES		
FOREST	CITY	
ndvi_avg(12)	ndvi_avg(11)	rainfall(9)
ndvi_var(12)	ndvi_var(2)	ctrl interv(4)
temperature_avg(12)	temperature_avg(12)	
temperature_var(11)	temperature_var(13)	

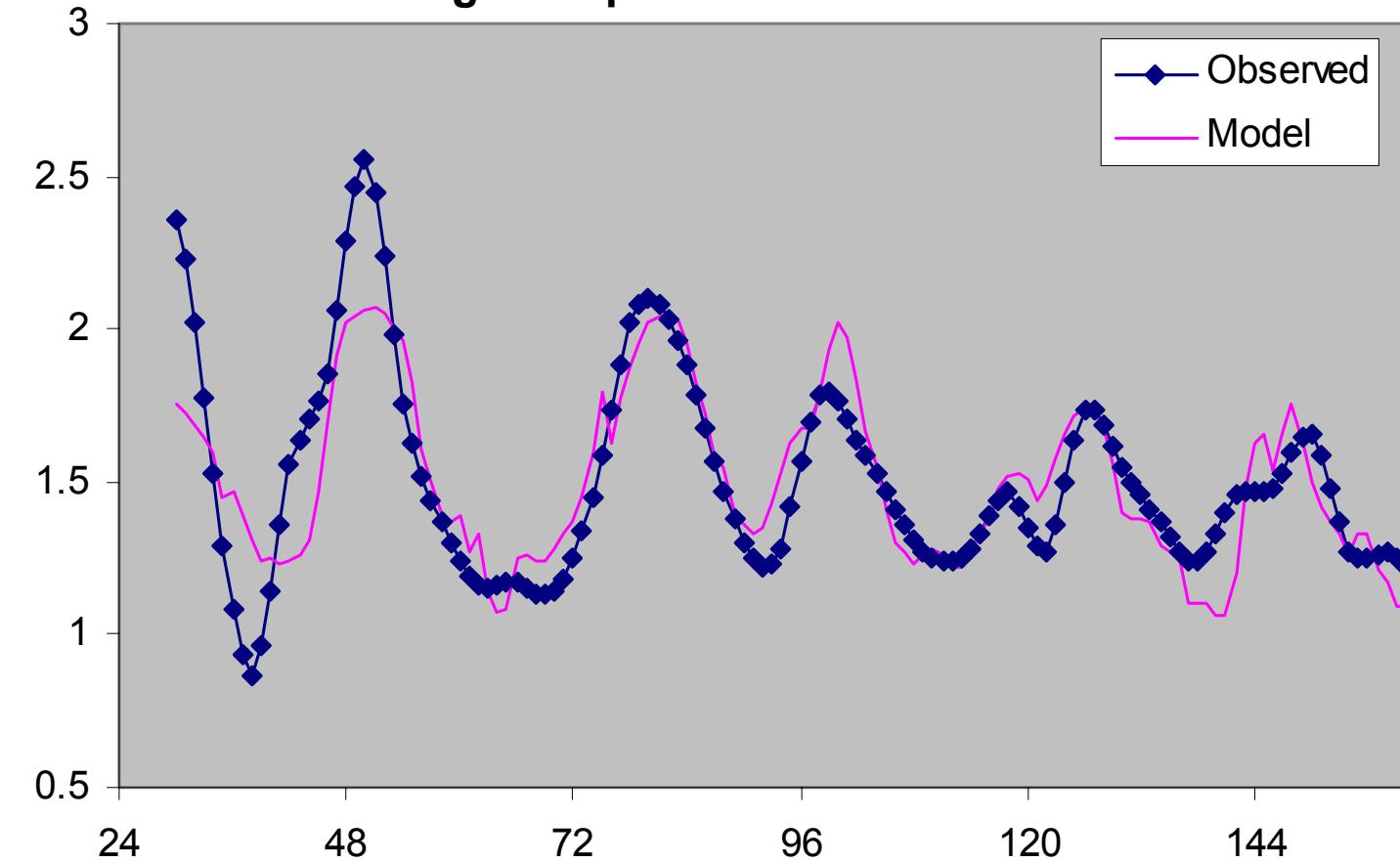


Breeding sites per house+. T24= Jan 1998



Field data after a spline function fit

Breeding sites per house+. T24= Jan 1998



TIME LAGS OF THE VARIABLES

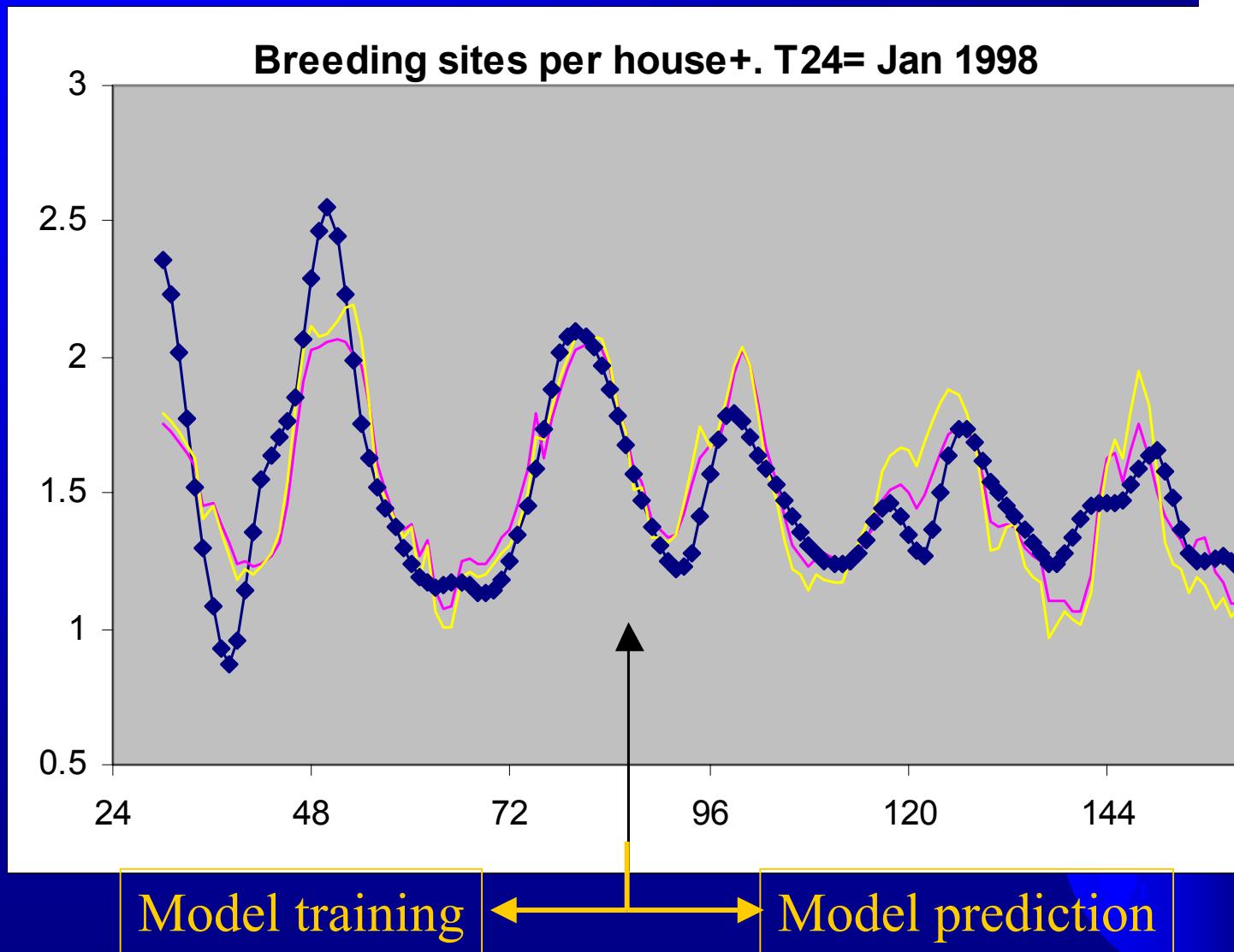
FOREST

ndvi_avg(11)
ndvi_var(11)
temperature_avg(11)
temperature_var(11)

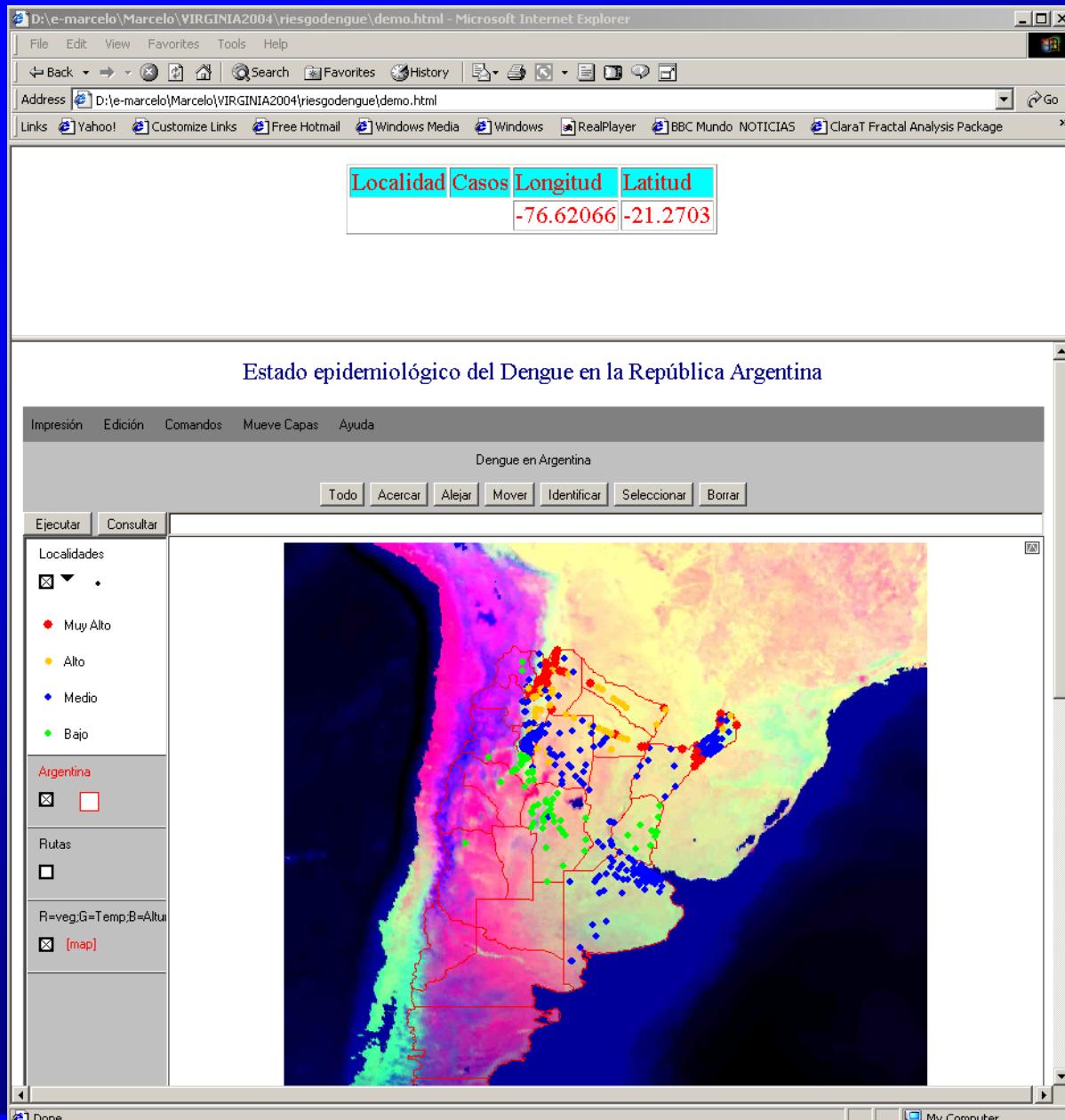
CITY

ndvi_avg(11)
ndvi_var(11)
temperature_avg(2)
temperature_var(11)

rainfall(12)
ctrl interv(4)



DENGUE RISK MAPPING

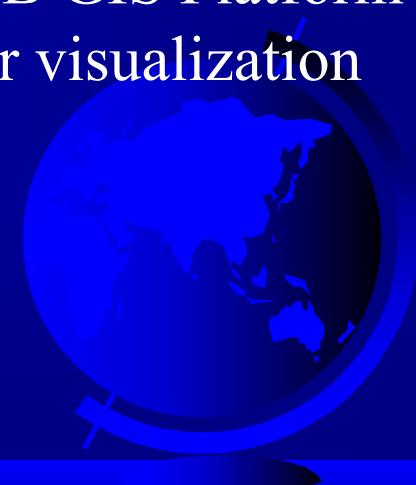


DENGUE RISK

Stratification

Using Field Data and Environmental Space Information

WEB GIS Platform
for visualization



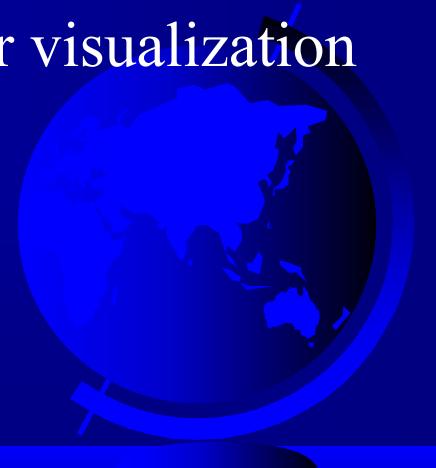
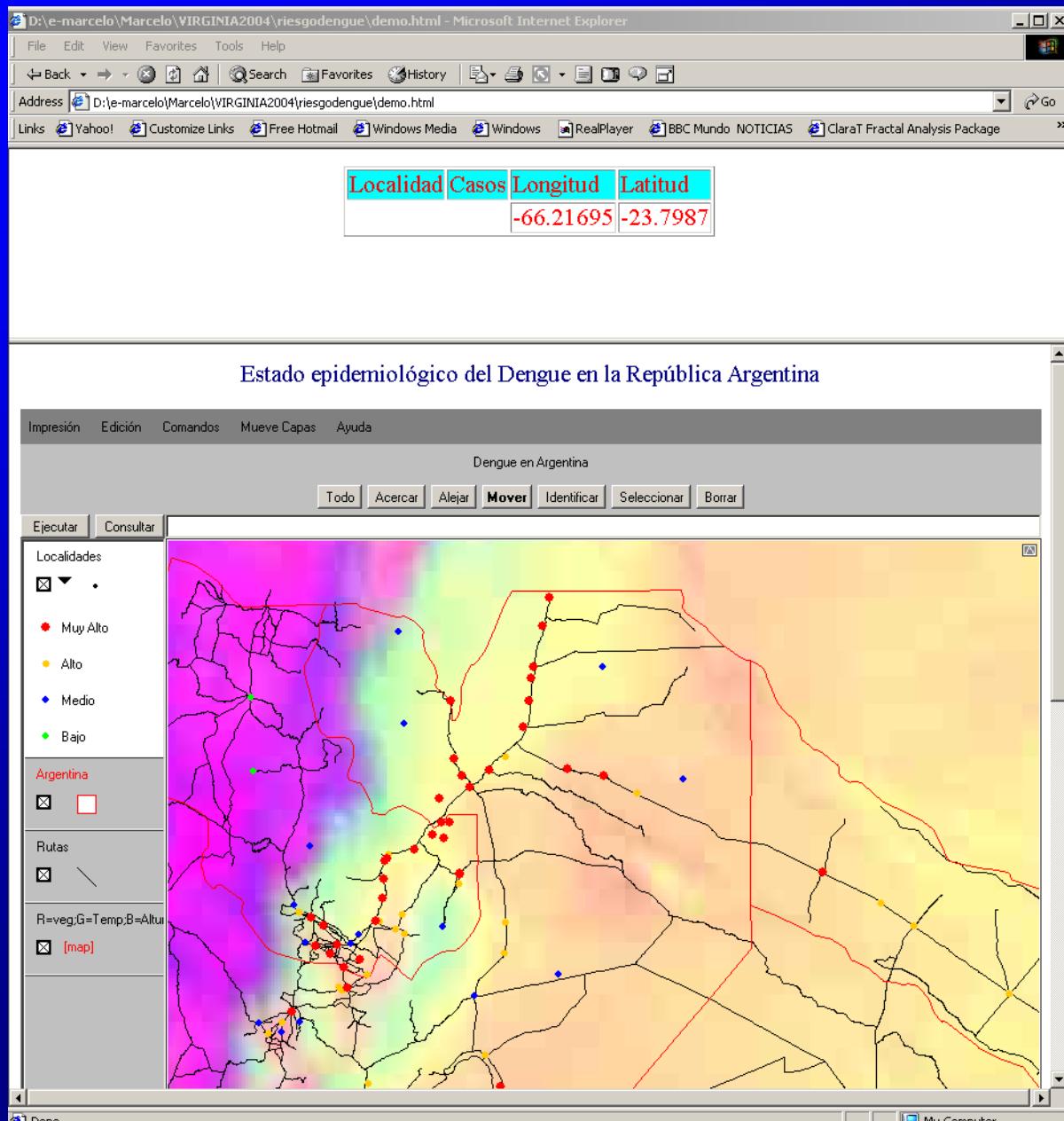


DENGUE RISK

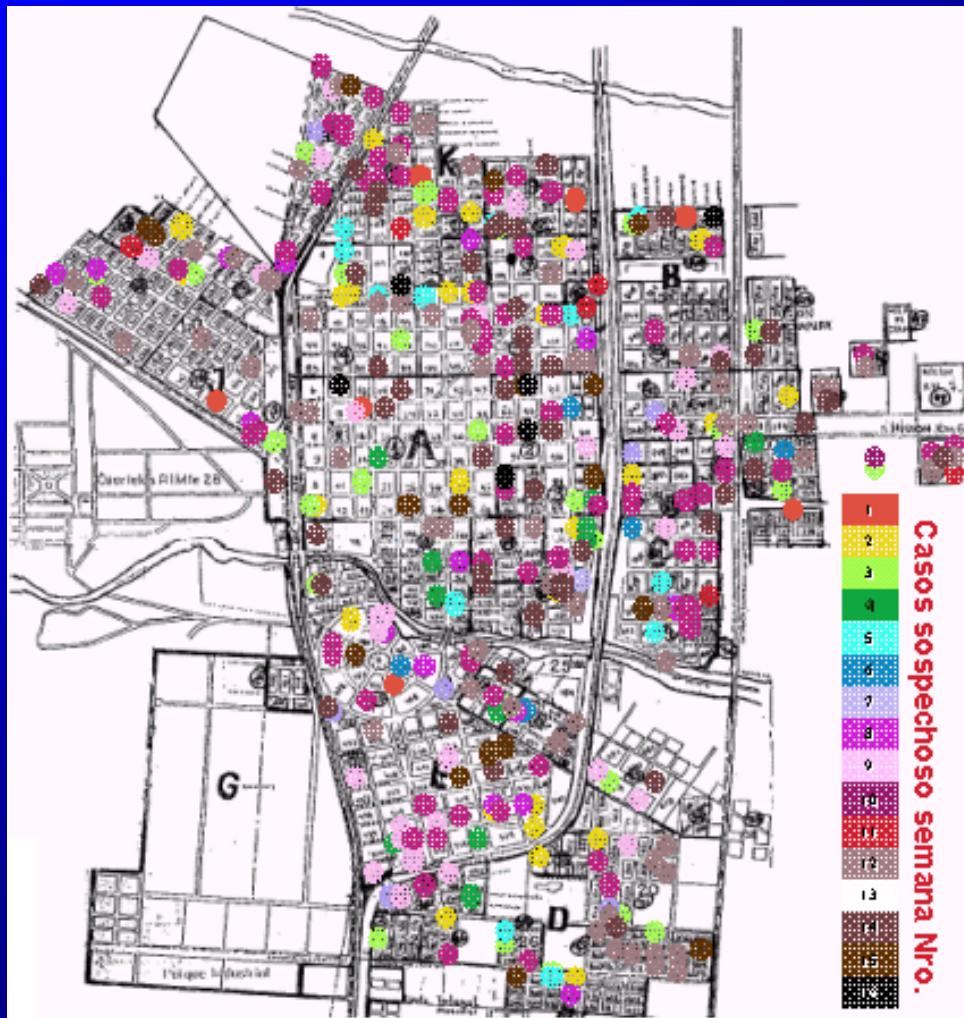
Stratification

Using Field Data and
Environmental Space
Information

WEB GIS Platform
for visualization

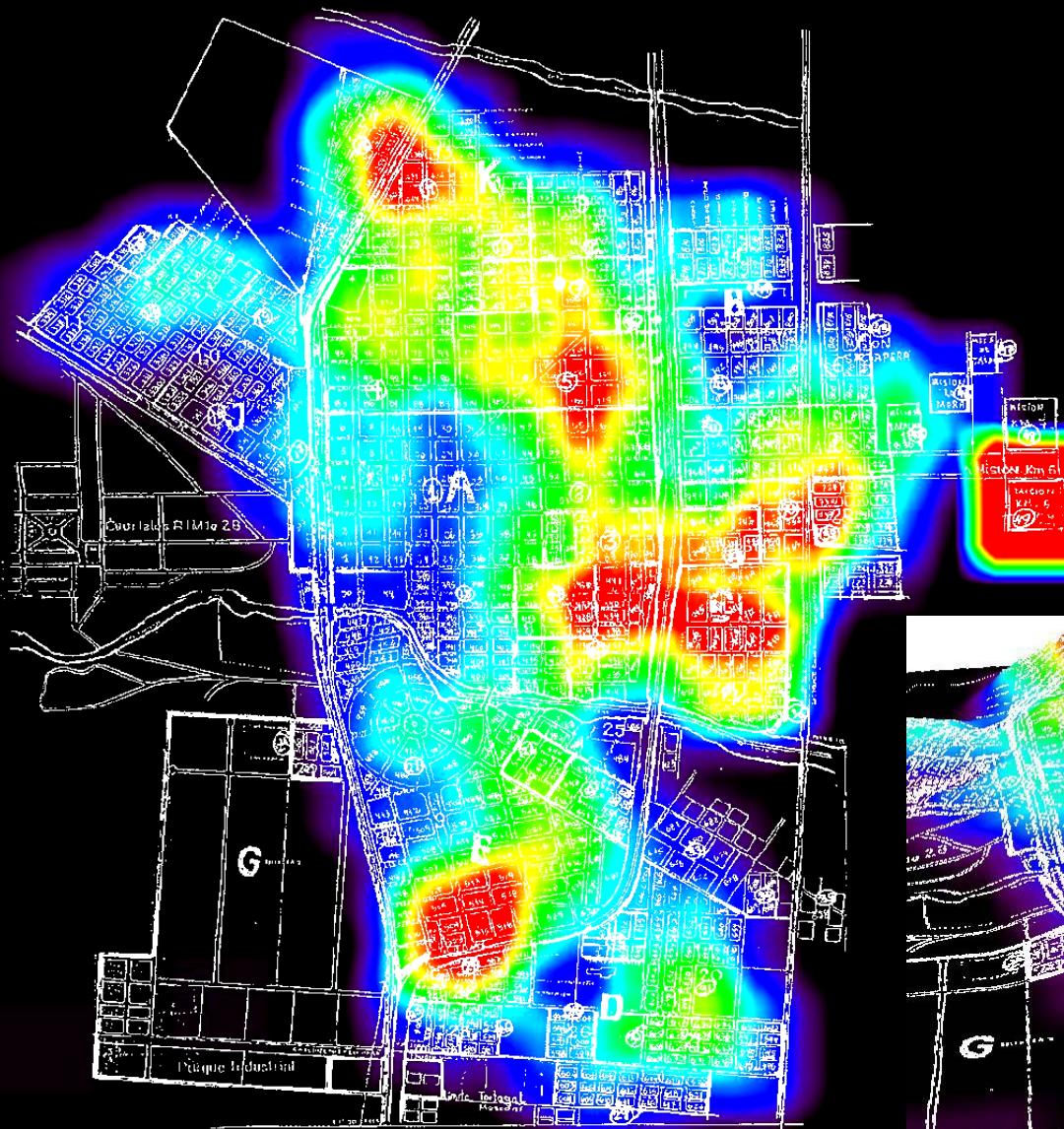


Tartagal outbreak 2003-2004

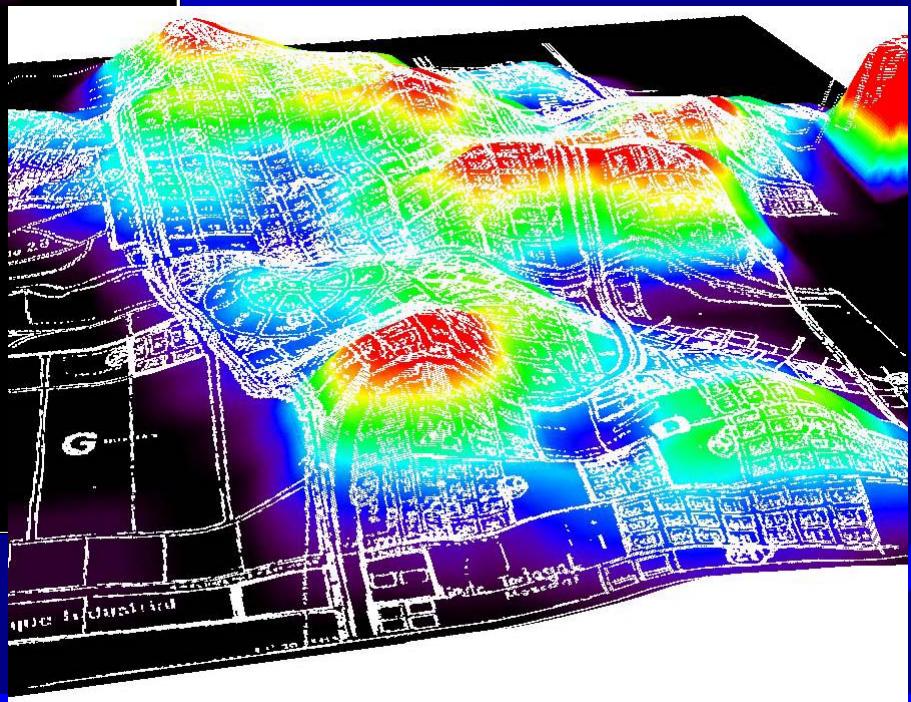


Cumulative Incidence FD. Tartagal

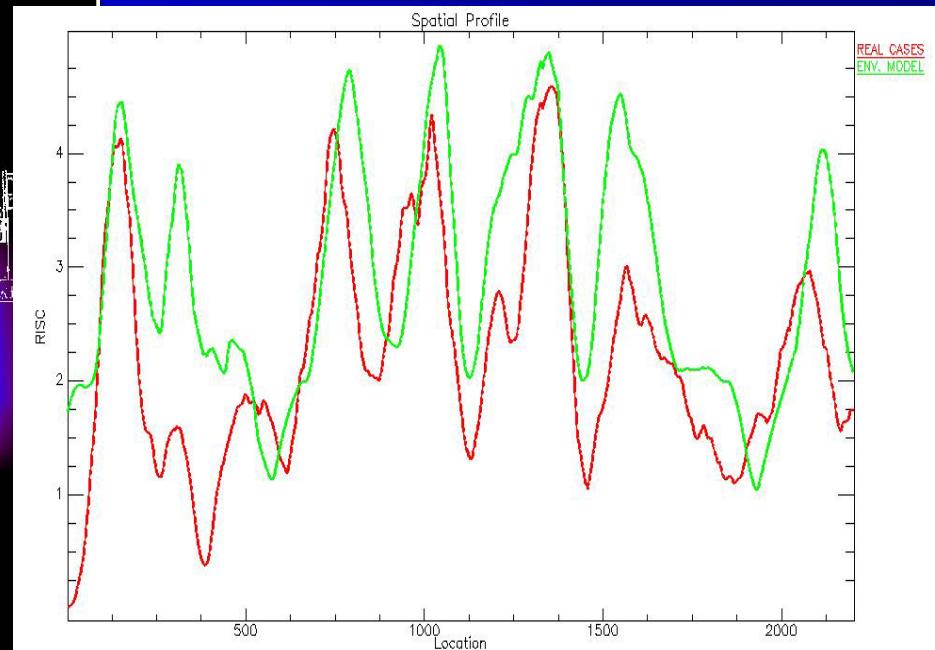
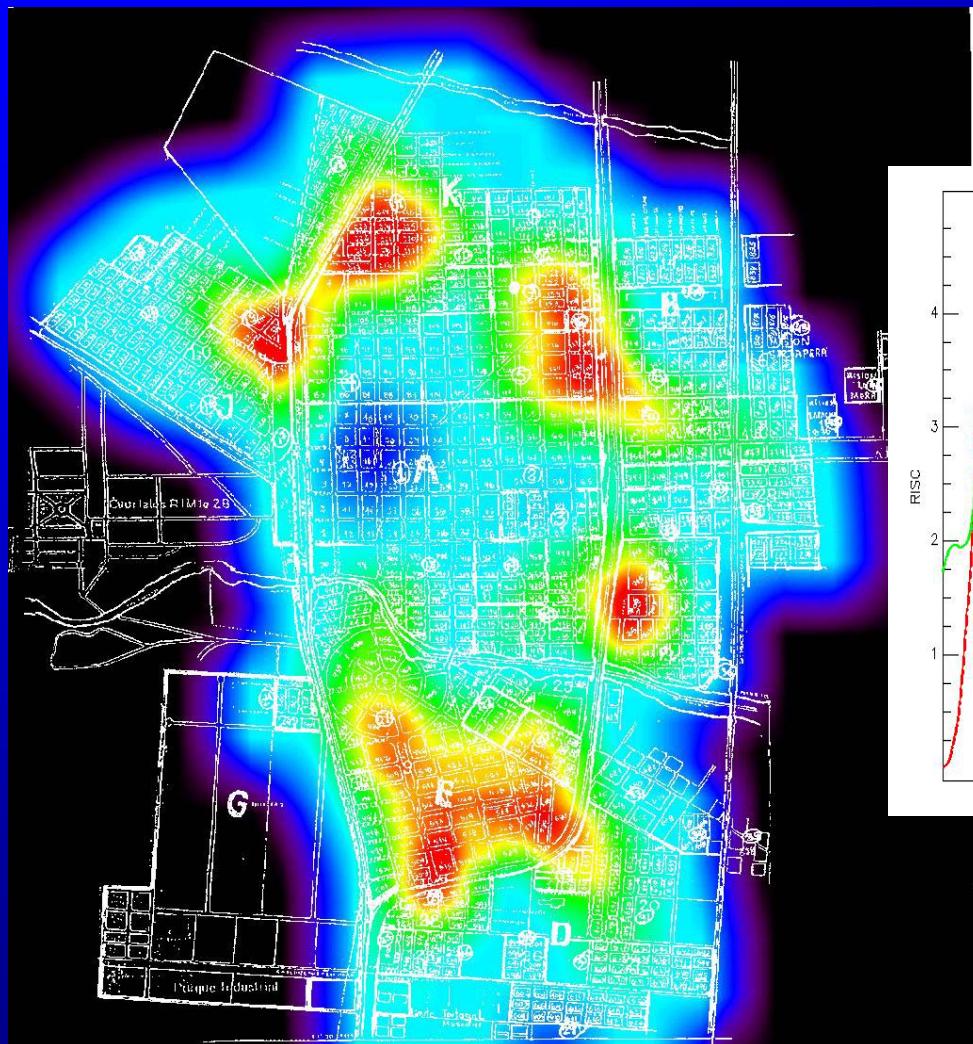
24 de Enero al 05 de Mayo de 2004.



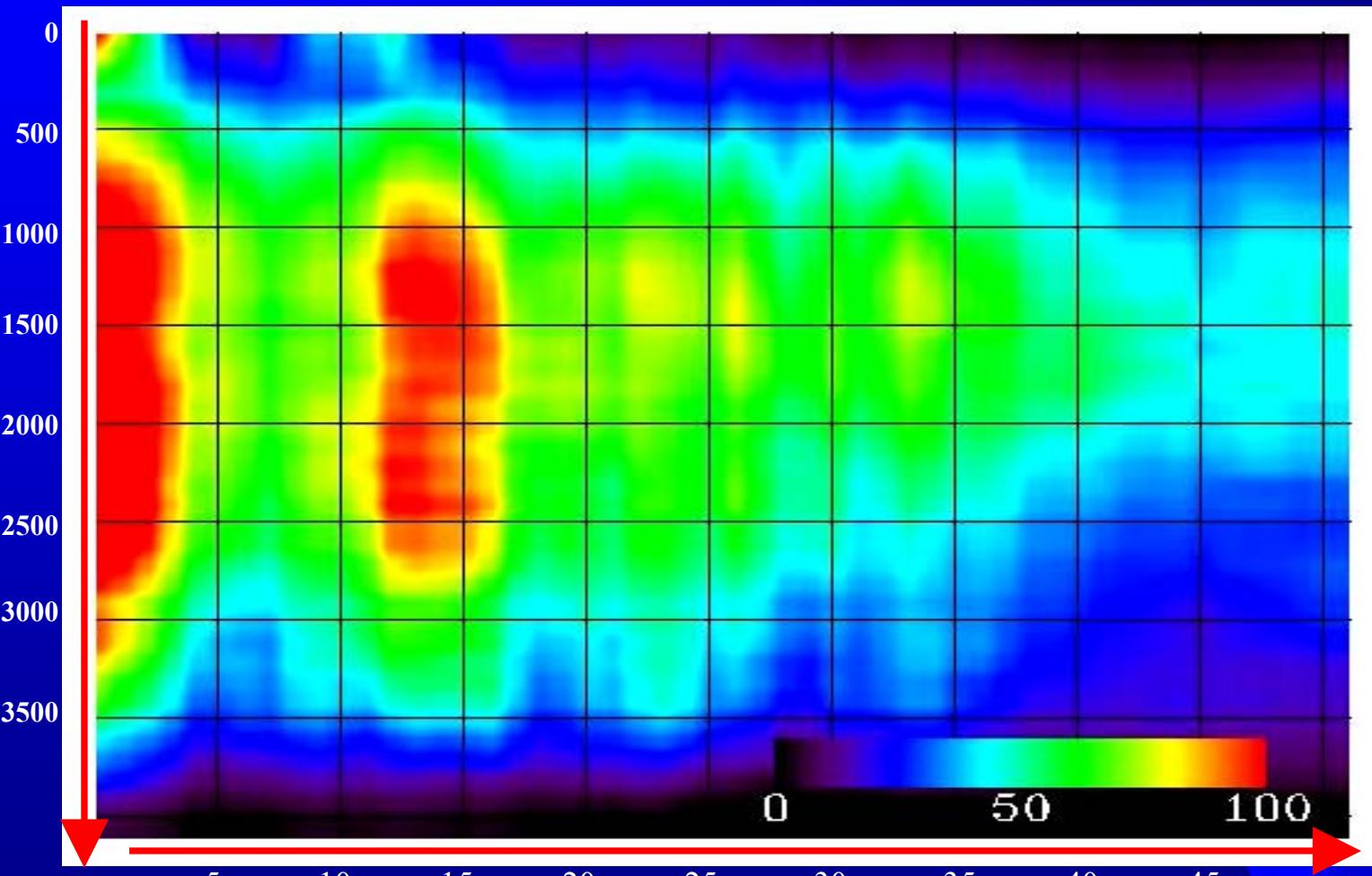
Mapa de Riesgo de Tartagal. Nro de casos sospechosos acumulados por Area de 400m X 400 m.



Macro-environmental Model



Space-Time Risk Mapping



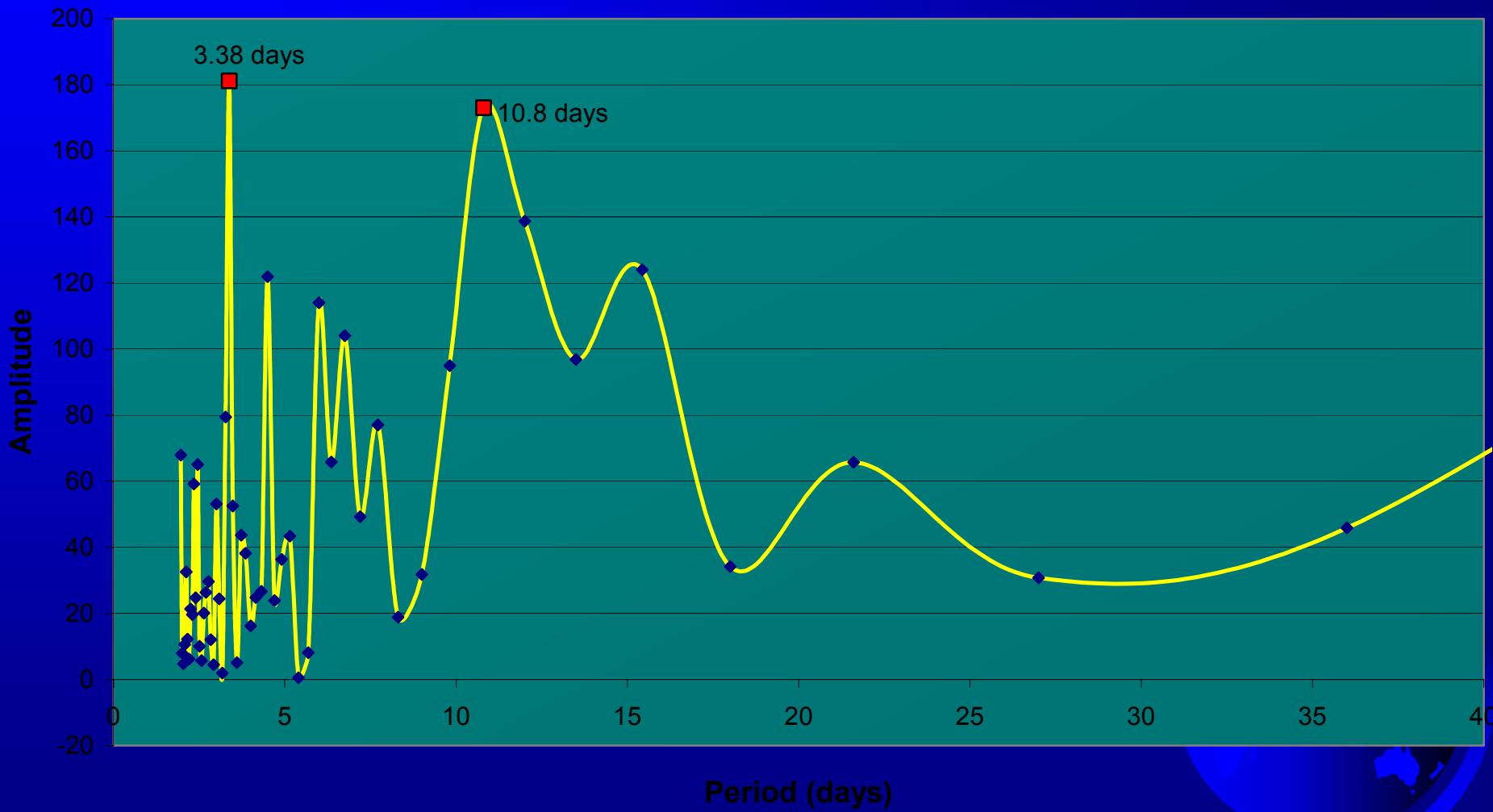
Nro of cases for each pair of data to a given distance

X: time distance (days) . Y: spatial distance (meters).





Fourier Analisys of previous data



RS and GIS Offer to Health

- New vision of the problems
- New tools for understanding
- Continuous monitoring of environmental conditions
- Health Early Warning Products

Health offer to RS community

- New *High Impact* Field of Application





Thank you

www.conae.gov.ar

[scavuzzo@cett.conae.gov.ar](mailto:scauzzo@cett.conae.gov.ar)

